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CONCEPTS EVALUATION MODEL V (CEM V) PART I, TECHNICAL DESCRIPTI--ETC(U)
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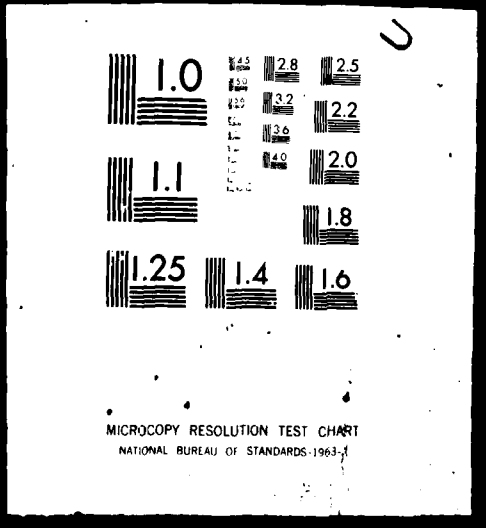

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The Concepts Evaluation Model (CEM) is a fully automated, deterministic combat simulation that can simulate months of theater land and air combat in a few hours on a computer. A unique feature of the CEM is the simulation and automation of the commanders' decision processes and utilization of resources at all echelons from division through theater. Results of combat are sensitive to the mix of major weapons within the combat forces, and the pace of combat depends on the expenditure and attrition of resources along with the associated resupply.
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Item 20 - Continued

This document contains a complete description of the latest version in the progression of CEM development, CEM V, encompassing the enhancements implemented at the US Army Concepts Analysis Agency up to September 1979. Major changes from previous versions of the CEM include the partitioning by national origin of Blue supplies and personnel, expanded command and control capabilities at echelons above division, and improved reporting of results.

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CONCEPTS EVALUATION MODEL V
(CEM V)

PART I - TECHNICAL DESCRIPTION

January 1980

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*Louer, P.E., Forrester, R.E., Parker, R.W., Shepherd, J.E., Tunstall, J.E., and Willyard, H.A., Conceptual Design for the Army in the Field Alternative Force Evaluation - CONAF Evaluation Model IV: Part I - Model Description; Part II - Input Derivations; and Part III - User's Handbook; General Research Corporation, McLean, VA, Dec 74.

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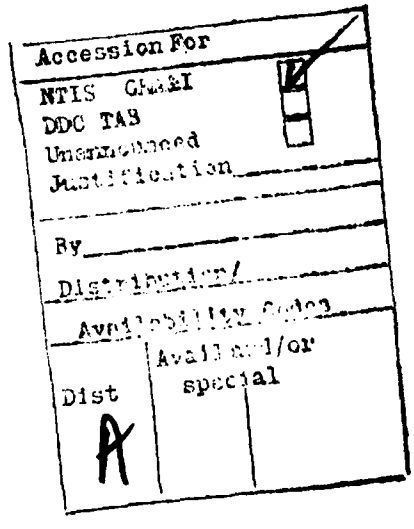

CONCEPTS EVALUATION MODEL V (CEM V)

PART I - TECHNICAL DESCRIPTION

CHAPTER 1

GENERAL FEATURES OF THE MODEL

1-1. BACKGROUND

a. The Concepts Evaluation Model V (CEM V) is the latest version in the progression of US Army theater force model development. This development goes back to 1968, when the theater Combat Force Requirements Model (TCM) was initiated at Research Analysis Corporation (RAC) as a part of the FOREWON research program. TCM was to provide an improved technique for determining theater force combat capabilities and requirements. In particular, the outcome of theater battle was to be properly sensitive to the mixes of combat units on both sides, and was to reflect command decisions concerning missions and allocation of available resources. As TCM became operational, the Army project, Conceptual Design for the Army in the Field (CONAF), came along with a pressing need for a force evaluation model matching; in general, the characteristics of TCM. TCM was then modified to satisfy this need, and became known as CONAF Evaluation Model I (CEM I).

b. Over the succeeding years, project CONAF went through several cycles of methodology improvements and applications. Many major modifications were made to CEM in this process, all aimed towards improving its capability to evaluate alternative theater combat forces. This work culminated in the CEM IV version, which was transferred to the Army in 1974. The name of the model was then changed to the Concepts Evaluation Model IV, still retaining the acronym CEM IV.

c. CEM IV has been subsequently used as the theater model for major Army force studies after its transfer to CAA. These include the CONAF V and CONAF VI Studies, the Total Army Analysis (TAA) annual studies to develop requirements for Army support force structure, OMNIBUS annual studies to assess current combat force capabilities, and Army materiel requirement studies. The model has been exercised well over 1,000 times in support of these studies, with most of these runs simulating theater wars up to 180 days' duration.

d. The onset of the Heavy/Light Study in 1978 highlighted the need to make further improvements in CEM IV. A radically different theater defense concept was being envisioned for Europe, and CEM IV could not simulate this concept. Major improvements were then accomplished to CEM IV for this study, resulting in CEM V which has been used in CAA studies begun during 1979.

e. The technical description of CEM V is contained within this volume. A companion volume is also being prepared describing all input values in the formats required to run the model (Part III, CEM V User's Handbook). Cross references are provided to assist in understanding the application of the input data within the CEM V operation.

1-2. BASIC STRUCTURE

a. The basic structure of the Concepts Evaluation Model V (CEM V) is portrayed in Figure 1-1. Primary inputs are: (a) the objectives and resources allocated to the theater by the opposing nations, and (b) information on the outcome of brigade-level engagements. Primary outputs are the forward edge of the battle area (FEBA) location and the condition or status (see para 1-9, Unit Status, below) of the opposing forces resulting from the consumption and/or depletion of resources along with the arrival of replenishments.

b. Referring to Figure 1-1, periodically at each echelon an estimate of the situation is made, and, on the basis of this estimate, a mission is selected and fire support is allocated to subordinate commands. This sequence continues down to brigade level, where the outcome of each brigade engagement (see para 5-4, Engagement Results, below) is determined. The results of such an engagement are a local change in the FEBA and a degradation in the condition or status of the engaged forces, i.e., a loss of men and materiel and a consumption of supplies. The condition of the forces may also be enhanced, depending on the amounts of resources provided them. These results are then aggregated at the various echelons, where they are used for the subsequent estimate of the situation.

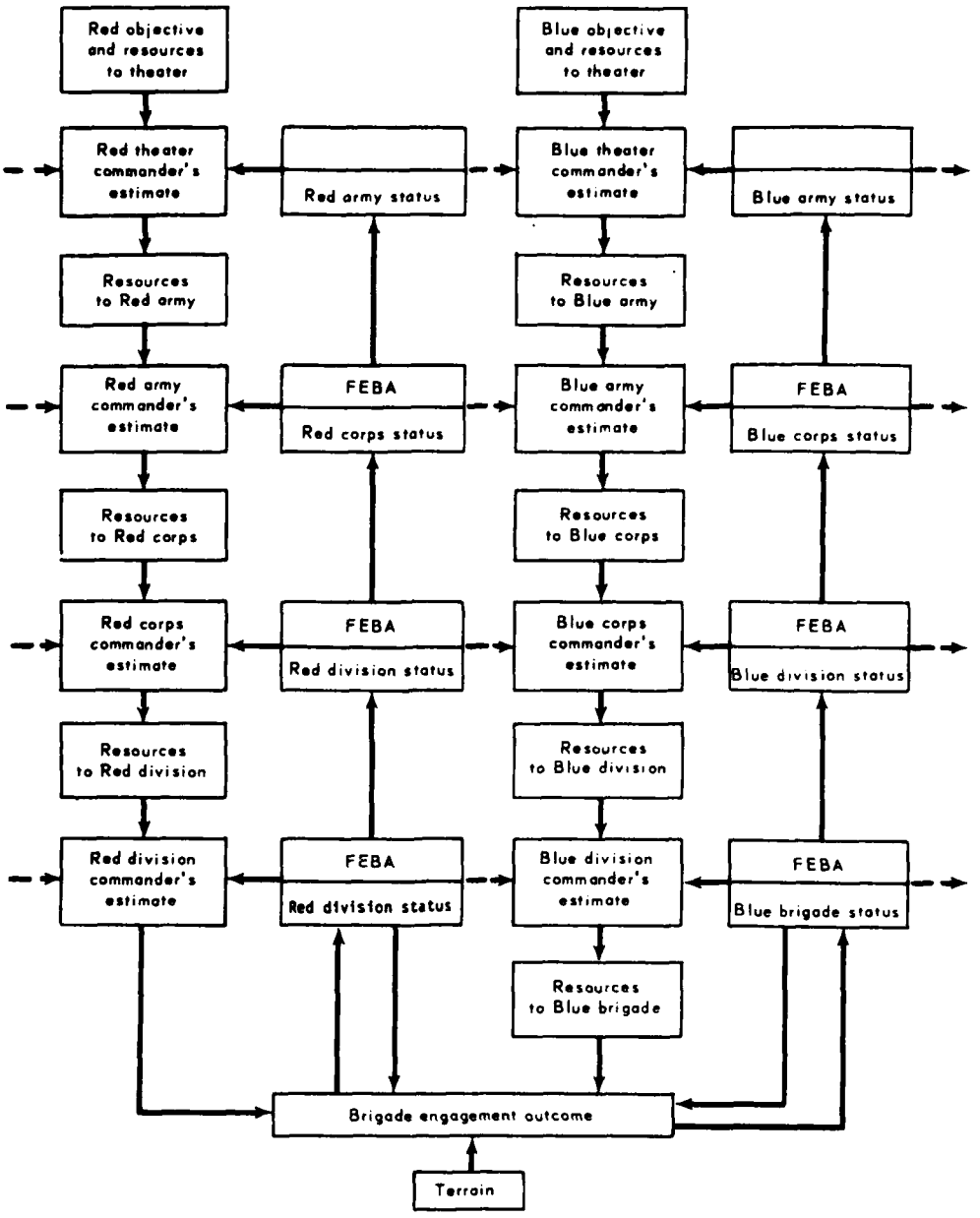

Figure 1-1. Concepts Evaluation Model Outline

c. For example, consider the box in Figure 1-1 labeled "Blue Corps Commander's Estimate" (of the situation). The army commander has allocated certain fire support to the corps, and the corps commander must then consider how he can best use this support. Specifically, he must decide what mission to undertake; how to allocate his corps artillery and cavalry among the divisions; and when and where to commit or reconstitute a corps reserve. He makes these decisions on the basis of his knowledge of his own forces, an estimate of enemy forces opposing him and their missions (the dashed line indicates imperfect intelligence), and calculations of various alternative results. The army commander went through such a process earlier, and the division commanders will make similar estimates as soon as they receive their fire support allocation. (All "estimating" and "decisionmaking" operations, of course, are automated.)

d. Air warfare effects are simulated in the CEM, although not indicated explicitly in Figure 1-1. The major roles consistent with tactical air doctrine are incorporated, together with a set of rules for the periodic allocation of available aircraft to these roles according to the progress of the air battle. Operations in the designated roles influence the air-to-air battle, speed of movement of supplies and reserve units, outcomes of individual brigade-level engagements, and subsequent role allocation of aircraft.

1-3. BATTLEFIELD REPRESENTATION. The CEM uses a simplified representation of the battlefield. Distances along the direction in which forces attempt to move are measured in kilometers with a minimum distance of one-tenth of a kilometer. Distances along the front are measured in minisectors (see Figure 1-2). Minisectors constrain force movement as the model does not recognize combat nor permit movement in the face of the enemy across minisector boundaries. Up to 1,000 minisectors may be employed across the entire width of the battlefield, with the space between minisector boundaries expanded or contracted under the influence of terrain, total battlefield width, urban areas, and other factors that would influence the movement of forces.*

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*As will be seen later, one input to the model is the minimum number of minisectors that a division front may occupy--which also may influence the contours of the minisector boundaries.

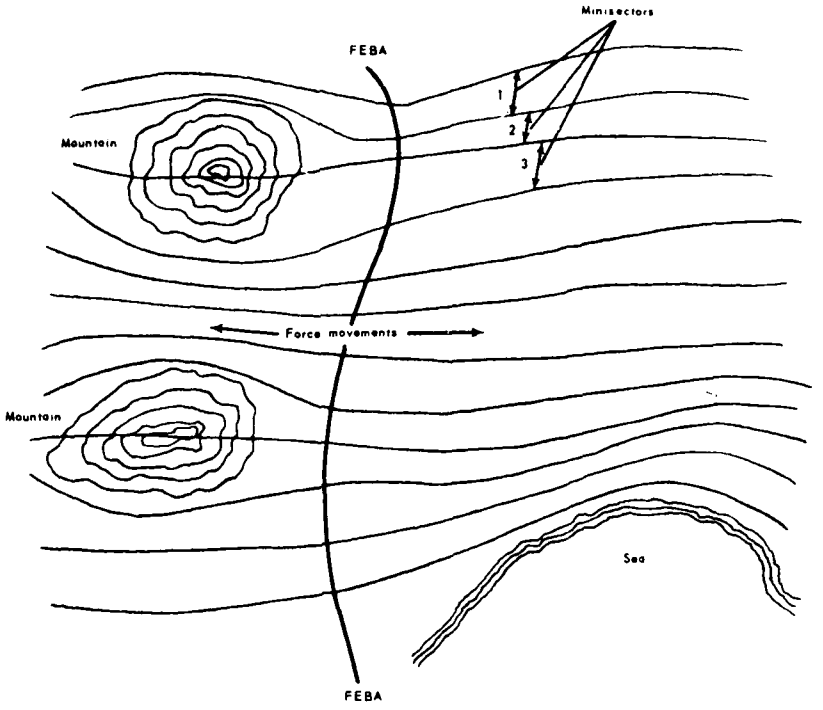

Figure 1-2. Battlefield Schematic

The effect of the terrain features on the spacing of the minisectors as they go through the mountains on the left, and around the body of water on the right, is that there is likely to be a higher density of forces where the minisectors are narrow, and a lower density of forces where the minisectors are wide. Since the fighting forces are generally constrained to move within the minisectors as initially laid out,* the realism of the simulation depends in part on the accuracy with which the planner can predict the probable real-life flow of forces.

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*Units in reserve or arriving reinforcements may cross boundaries behind the FEBA. Also armies and corps who are defending or delaying may expand or contract subordinate unit frontages across minisector boundaries.

1-4. TERRAIN DESCRIPTION

a. The terrain is divided into four types, all of which have some bearing on the mobility of ground combat units. The first three types reflect the general nature of the terrain. They are:

Type A - This terrain is flat to gently rolling with a minimum of timber. It is excellent tank country.

Type B - This terrain is marginal for tanks and wheeled vehicles because of topography, soil conditions, or vegetation.

Type C - On this terrain tanks and wheeled vehicles must remain on the roads because of steep slopes and/or dense forestation or swamps.

The fourth type of terrain, Type D, is intended to represent some major obstacle that would normally require extra or special effort for the forces to negotiate or pass through. It may be a river, lake, marsh, canyon or some man-made barrier, such as a minefield. To be identified as D terrain, a barrier must extend across the battle area far enough to affect more than a division front.

b. A basic assumption is made that a successful crossing of this barrier will consume the major portion of a division period.* Thus, D terrain is considered by itself in the model and not in combination with any other terrain types for any division period outcome. The minimum movement in the model is one-tenth of a kilometer, so the minimum distance of FEBA movement in crossing D terrain is necessarily that amount.

c. Terrain is resolved in depth to the nearest tenth of a kilometer and laterally into terrain bands, each of which is a given number of minisectors in width. For example, a given terrain band, 10 minisectors wide, may contain 5.2 km of Type B followed by 18.0 km of Type A followed by 0.1 km of Type D, etc.

1-5. INITIAL DEPLOYMENTS. The initial forces, resolved to brigade for Blue and division for Red, are deployed on the map. These forces must be aligned so that their boundaries fall on minisector boundaries, but the organizational boundaries of the opposing forces do not have to line up across the FEBA. This is

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*See para 1-7, Time Periods.

illustrated by Figure 1-3, showing a Blue force on the left opposing a Red force on the right. (All minisector boundaries are not shown on this figure, only the ones coincident with brigade and division boundaries.) A Blue brigade front (such as the distance AB) or a Red division front (such as EF) is defined as a sector. The sections of the FEBA defined by consecutive organizational boundaries of Blue and Red (such as the distances AE, EB, BF, etc.) are called subsectors. As will be seen later, estimates of the situation are made by sector fronts, but engagements are assessed by subsector.

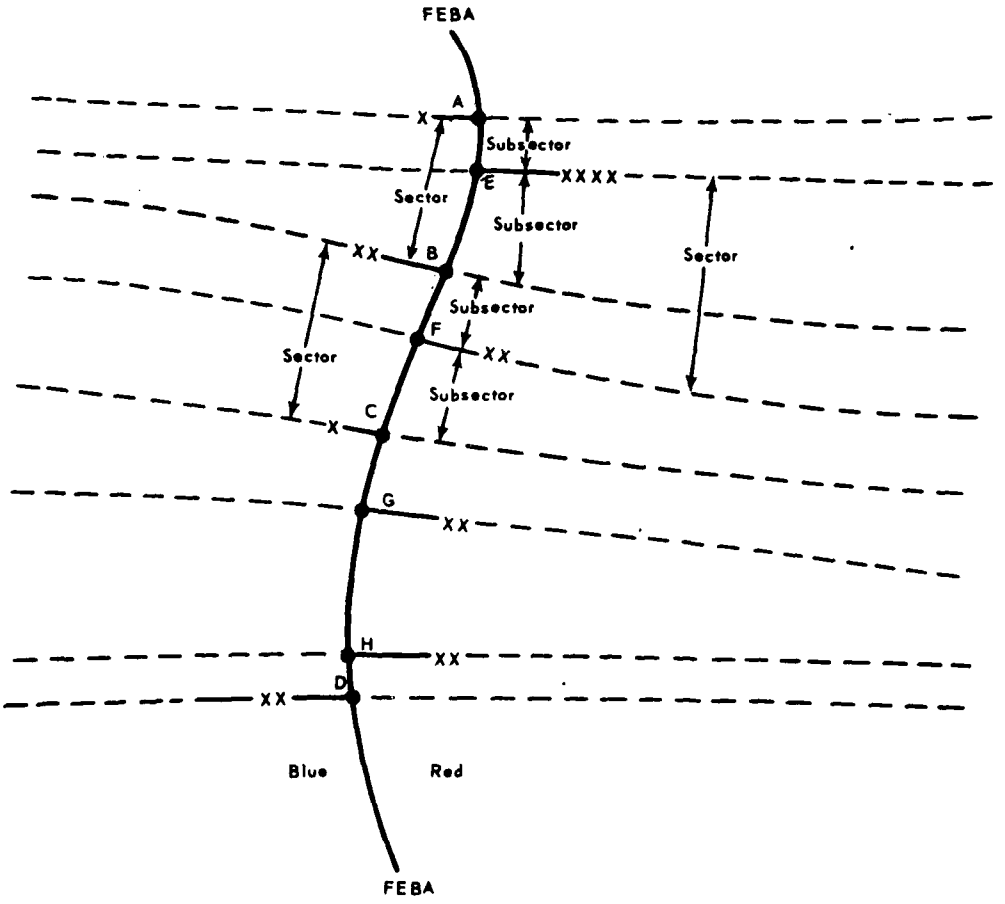

Figure 1-3. Initial Deployments

1-6. ORGANIZATIONAL CONSTRAINTS

a. Number of Subordinate Units under Parent Unit. The only forces simulated in the model are combat units. The theater force is composed of field armies, each of which may consist of two to five corps. A corps consists of one to five divisions plus corps artillery battalions and a corps cavalry unit.* Each Blue division consists of three brigades plus division artillery battalions and a division cavalry unit.* Brigades and cavalry units are made up of arbitrary numbers of maneuver battalions and their composition remains unchanged during a play of the model. Red divisions have no subordinate units.

b. Reserves. Reserves at corps and division echelons, if they exist, consist of exactly one of the next lower unit. For example, a corps may have one division in reserve, or none. At the army echelon, reserves may consist of a corps and an army reserve pool which may contain zero to nine divisions.

c. Resolution of Combat Capability. The CEM simulates combat between Blue brigades and Red divisions or fractions thereof. However, the combat capabilities of these units are based on the capabilities of the battalions and regiments they comprise. Each Blue brigade and Red division is initially defined in the CEM by the number and variety of its battalions (Blue) or regiments (Red) and that composition does not change during a run. The combat capabilities of the Blue battalions and Red regiments are given in terms of their personnel, supply, and major weapons on hand. Supporting the combat between the Blue brigades and Red divisions are artillery battalions and close air support (CAS) on both sides and, on the Blue side, division and corps cavalry units.

d. Maximums on Types of Unit and Weapon

(1) One of the virtues of the CEM is that it can differentiate the firepower capabilities of any reasonable number of different types of maneuver units. The maximum number of types of battalions or regiments that can be simulated in a given run is 50.

(2) The number of maneuver battalions that can be placed in a Blue brigade or cavalry unit is essentially unlimited, the number of any given type being limited to 15. The same limitation applies to the Red regiments.

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*The cavalry unit is optional, i.e., a corps (or division) may have either zero or one cavalry unit.

(3) The force being simulated (Blue or Red) may contain up to 8 different types of cannon, which may be incorporated into as many as 15 different artillery battalion types. Each artillery battalion may have a maximum of three types of cannon.

(4) Direct support (DS) artillery battalions are assigned to Blue brigades and Red divisions (input). Each brigade may have a maximum of one DS artillery battalion, however, the type may vary between brigades. The Red division may have up to five DS battalions of one type only. The type of DS battalions may vary between Red divisions.

(5) Each Blue and Red division may be assigned a maximum of five general support (GS) artillery battalions of one type per division. The army and corps general support artillery may consist of one or more of any of the first eight artillery battalion types described to the model.

1-7. TIME PERIODS

a. Each echelon above brigade has an associated time period, roughly the time within which a change in mission is unlikely. The period at each echelon is an integral multiple of the period at the next lower echelon. The following periods are currently used: division, 12 hours; corps, 1 day; army, 2 days; theater, 4 days.

b. Once each period, an estimate of the situation is made at the corresponding echelon, leading to mission selection, allocation of fire support, and commitment or reconstitution of reserves. When the beginnings of periods of more than one echelon coincide, the higher echelon decisions and allocations are treated first so that the lower echelon may act within the constraints of these decisions.

1-8. ESTIMATES OF THE SITUATION

a. Estimates of the situation on which the above decisions and others are based occur at the army, corps, and division levels. No estimate is made at the theater level since the activities at that level are not dependent on an estimate and resulting mission.

b. The estimate of the situation consists of a comparison of one's own strength with that of an estimated enemy. Both strengths consist of the numbers of different types of maneuver and artillery battalions coupled with an assessment of their fighting capabilities in light of a mission that is being considered. The general rule for mission consideration is to strive

for the most aggressive mission that is believed to be attainable in terms of the situation. Thus, the order of mission consideration is: (1) attack, (2) defend, and (3) delay.

c. When the commander, for the purpose of estimating the situation, is counting his own strength, he counts the strength of those battalions that are considered capable of the mission under consideration (see para 1-9d, Brigade State). When he is counting the opposing strength he counts the strength of those estimated battalions that are considered capable of the complementary mission. The count of his own battalions is accurate. The count of the enemy is an approximation based on what was opposing his sector in the recent past and on his intelligence capability. An assessment of the fighting capability of the counted battalions is then made to arrive at a comparative strength of the two sides.

d. For the purpose of estimating enemy strength, history arrays are maintained for both sides at each of the three echelons, i.e., army, corps, and division, for the two most recent cycles. At each echelon the array for each cycle includes:

(1) The location of each on-line unit of the next lower echelon at the beginning of the cycle.

(2) A measure of the strength of each on-line unit of the next lower echelon at the beginning of the cycle for both offensive and defensive operations.

e. Intelligence capability:

(1) By use of intelligence coefficients and the above history arrays, a unit at a given echelon makes an estimate of the strength opposing him. The effect of the intelligence coefficients is to reflect a time delay on his information. This is accomplished by using the coefficients to weight the enemy strengths that opposed his position in the two preceding cycles. In the army and corps cycles these strengths are associated with a mission complementary to his own. At the division level, the commander also makes an estimate of the enemy mission.*

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*Different coefficients are used for the opposing artillery than are used for the maneuver element estimate.

(2) An optional intelligence capability can be given to the Blue side that makes its intelligence more current. By the use of this option the coefficients identified above are applied to the Red strengths in the current and preceding cycles respectively. This option has the effect of making the information time lag vary between zero and one time period at the given echelon rather than between one and two time periods.

1-9. UNIT STATUS

a. In estimating the situation, each unit must arrive at a measure of the strengths of his own forces and of those opposing him. A component of this measure is the state of each unit which is in turn an approximation to the unit status. The unit status is a detailed representation of the combat capabilities and shortages for combat undertakings on the one hand and resupply operations on the other. A status file is maintained for each Blue brigade and cavalry unit and for each Red division to include men, supplies, and numbers of major items of equipment. A status file is also maintained for each divisional artillery battalion to include men, ammunition, and cannon. A single status file is maintained on each side to include all nondivisional artillery.

b. Input status files are constructed at the Blue battalion level and at the Red regimental level (battalion level for artillery) and from these the initial brigade, cavalry, and division status files are constructed. The artillery units are also constructed from input artillery battalion status files.

c. During the engagement phase, the status files of the above units are modified to reflect casualties, losses of equipment, and consumption of supplies. The resulting deficiencies in the status files are used as the basis to requisition resupply and replacement.

d. From the values in the status file, a single measure is derived as a means of determining the missions that the brigade can undertake (not necessarily successfully). This single measure is called the brigade state. A brigade whose state is high enough to undertake an attack mission can attack, defend, or delay. A brigade whose state limits it to the defend mission can also delay, but it cannot undertake an attack. If the brigade state is so low that it is limited to the delay mission, it may not undertake any other mission. The state concept is also applied to Red divisions. Unit state is used as a multiplier of full strength

firepower during the estimate of the situation to identify the fighting capability of battalions that are included in the estimate.*

e. The state is defined as 100 times the current combat capability divided by the full strength combat capability in a meeting engagement. The combat capability is the total sum of firepower from the status file (where current values are used for current capability and full strength values are used for full strength combat capability) constrained when necessary by supply shortages. (For details on supply constraint, see para 5-3, Effective Firepower Development). The state concept thus involves a scale of zero to 100, with thresholds defining the minimum allowable brigade states for the various missions to be undertaken.** The current state of each brigade is a single number on this scale, determining which mission(s) the brigade is allowed to undertake by which threshold(s) it exceeds. The state is degraded through loss of men and major items and supply consumption in combat, and is enhanced by the arrival of resupply and replacements.

1-10. MISSION SELECTION AND RELATED DECISIONS. The estimate of the situation for the commanders at army, corps, and division levels leads to the selection of missions and whether a reserve will be retained or reconstituted. The selections of the missions influence the allocation of fire support to subordinates. This allocation of fire support in turn influences the aggressiveness of the subordinate units as they are selecting their missions. Other decisions made by the separate echelons will be enumerated subsequently under headings for the same. The greatest number of decisions are made at the division level. It is at the division level where this multitude of decisions leads to the combat engagements. These then determine the course of the campaign and lead through changing situations to new decisions.

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*When the state of a higher echelon unit is referred to, it represents the average state of all maneuver battalions within that echelon unit. For this calculation, all maneuver battalions within a brigade are at the same state level--that of the parent brigade.

**For the attack mission, an alternate mission threshold can be specified, which will apply to Blue brigades during a specified span of division cycles.

1-11. ENGAGEMENTS

a. After all decisions have been made in a division cycle the engagements are assessed, subsector by subsector, across the front. An engagement situation is described by the following characteristics:

(1) The strengths of the opponents as displayed by the various entries in the status files of each (including on the Blue side proportional amounts from the supporting cavalry units).

(2) The number of types of artillery battalions in support.

(3) The number of CAS sorties.

(4) The type of engagement.

(5) The type of terrain.

From the above components an array of effective firepower is constructed in such a way that it allows the matching of types of firepower with types of target. The firepower that is constructed from the status file entries is a function of the number of weapons by type, the amount of supplies on hand and the type of engagement occurring. Before it is used against the particular types of targets available, it is also modified to reflect the type of terrain over which the engagement is taking place. The particular types of firepower coming out of the status files (from the Blue brigade and supporting cavalry units on the one side and from the Red division on the other) are grouped by source into hard (i.e., from tanks), medium (from light-armor), soft (from personnel), and helicopter.* To this firepower is added that from two more sources, the support artillery** and CAS. The firepower from each source is further categorized by its capability as antitank, antilight armor, and antipersonnel.

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*Helicopter firepower for Blue comes only from the supporting cavalry units. There are no helicopters placed in the front-line brigades. Red helicopters are included in the division status files.

**The DS artillery may be reduced or partially neutralized by fire from the opposing GS artillery.

b. The results of each engagement are calculated from algorithms that take both the firing weapons and the target vulnerability into account. The results of the engagement assessment are the following:

(1) The number of casualties (killed, wounded, and missing).

(2) The number of major weapons by type damaged and destroyed.

(3) The direction and distance that the local FEBA moves.

(4) Consumption of supplies during the engagement.

To these results are added the nonbattle losses to men and major weapons. (The nonbattle losses are applied to the reserve units as well.)

1-12. ARTILLERY REPRESENTATION AND EMPLOYMENT

a. Direct support artillery battalions and GS battalions organizationally assigned to divisions are all represented discretely in CEM, with individual status files maintained for each of these artillery battalions. On the other hand, all nondivisional GS battalions specified by inputs for each side are combined (by the CEM) into a single status file, which then includes the total conglomerate of nondivisional artillery weapons. For allocation, this status file is divided into composite battalions, each of which is a fractional part of the large status file. The number of composite battalions represented is equal to the total number of various nondivisional battalions specified through inputs (times 10 for ease of integer handling in the CEM). This large status file is maintained in the usual way for expenditures and resupply, and it can be updated by the addition of reinforcement artillery battalions.

b. The employment of DS battalions is confined to the DS role, the effects of which are realized in the outcome and results of the engagements. The employment of GS artillery may be distributed among the roles of: (1) reinforcing DS fire, (2) counterbattery fire against enemy DS battalions, and (3) fire against maneuver units in reserve. The effects of counterbattery fire are partial neutralization, losses of cannon, and personnel casualties within the DS battalions under fire. General support fire against maneuver units in reserve results in personnel casualties and equipment losses.

1-13. REPRESENTATION OF LOGISTIC FUNCTIONS

a. The CEM represents four basic logistic functions in varying degrees. They are supply, maintenance, personnel care, and transportation (see Figure 1-4). Resources are made available during each theater cycle (representing resources from theater stockage and from ports) and are placed in theater distribution pools after a given time delay associated with transportation and handling. From the theater pools the resources are delivered to the brigades and cavalry units (Blue) and divisions (Red) during the ensuing division cycles on the basis of need. The theater distribution pools also receive personnel returned from theater hospitals and weapons repaired in theater on a time-phased basis that reflects the evacuation policy and capacity of the maintenance facilities.

b. Each combat unit has an authorized strength, equipment list, and initial load and also has a current status of these resources as reported in its status file. The resources in the theater pools are distributed to the units as a function of unit need to replace losses and consumption during each division cycle.* If theater resources exceed the requirements of the combat units, then the excess resources are conserved for the next division cycle.

1-14. CYCLES.

As suggested earlier, a cycle of events takes place at each echelon once during each appropriate time period. This runs generally as follows: estimate of the situation, decisions, engagement results and new estimate of the situation, etc. The following discussion is organized into sections, each of which describes the cycle of operations occurring at one echelon.

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*For Red, this applies to supplies but not necessarily to replacement of men and major weapons. See para 4-2, Red Division Replacement.

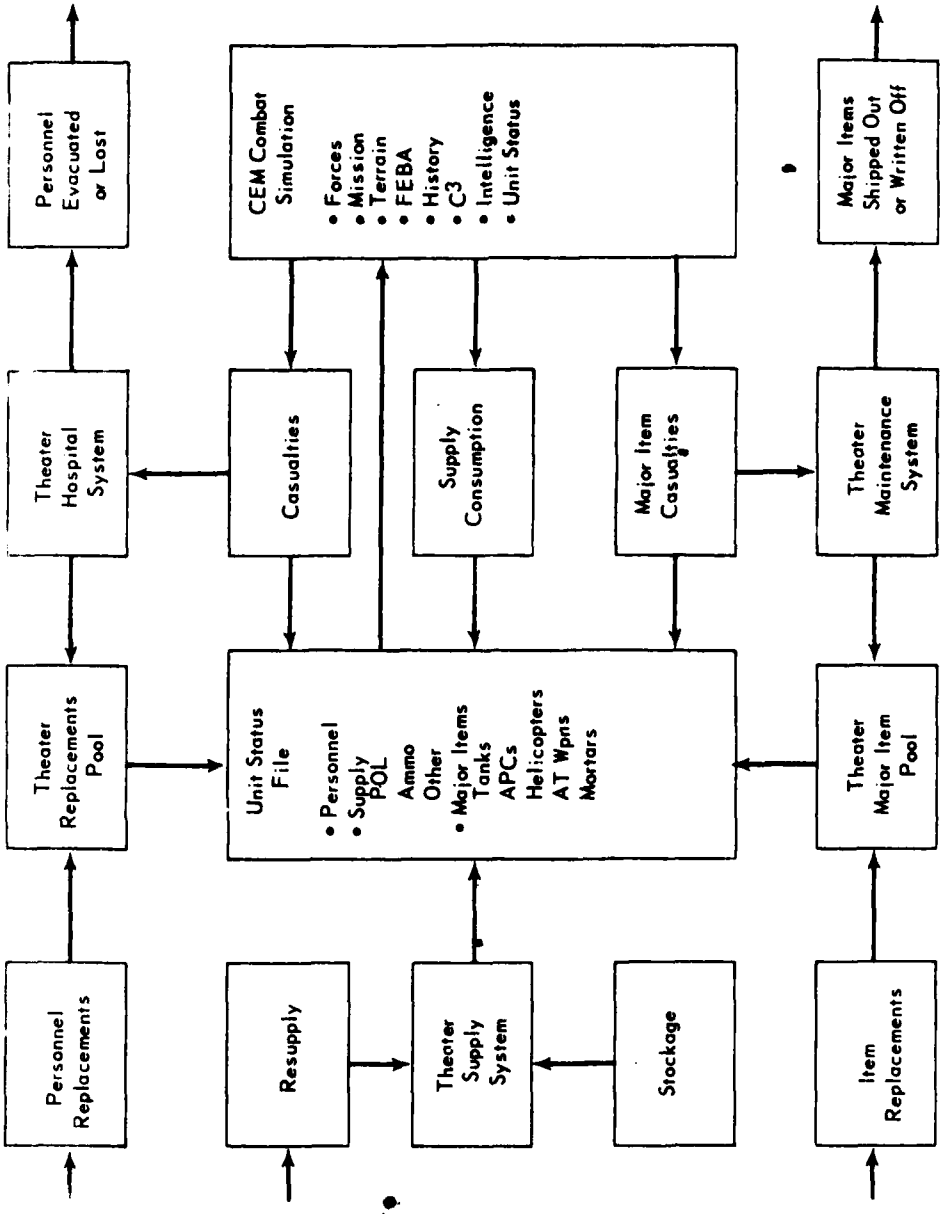

Figure 1-4. Schematic Diagram of CEM Logistic Support Systems

CHAPTER 2

THEATER CYCLE

2-1. THEATER DECISIONS

a. Three decisions are made at the beginning of each theater period. The first concerns the assignment of reinforcement artillery battalions to armies. This assignment is made in proportion to the number of divisions in the armies. Reinforcement artillery is assigned once each theater cycle.

b. The second decision concerns CAS sorties, which are also allocated to armies in proportion to the number of divisions in each army. (The number of aircraft sorties available for CAS in the theater as a function of time is determined in the Air Model.)

c. The third decision concerns logistic resupply operations which comprise all logistic operations above division level, the details of which are treated next.

2-2. REPRESENTATION OF LOGISTIC FUNCTIONS. The four basic logistics functions exercised during the theater cycle are supply, maintenance, transportation and personnel care. Available resources are separated into equal theater pools* to be delivered to the combat units during the division cycles within the theater cycle. Personnel returned from theater hospitals and weapons repaired in theater on a time-phased basis are also added to the theater pools.

a. Supply Support. All supplies for combat units are introduced into the CEM at theater level, and the quantity available may vary from theater cycle to theater cycle as desired. This allows representation of theater stockage levels and resupply from CONUS or other sources on an aggregated basis. Five categories of supply are independently considered: POL (Class III), ammunition (Class V), all other supplies necessary for combat units, major weapon replacements, and personnel replacements. POL, ammunition, other supplies, and personnel replacements can be partitioned among as many as three distinct nationalities on the Blue side.

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*A different set of pools is used for each type of major item, each type of supply, and for personnel.

b. Maintenance Support. Attack helicopters, tanks, and light armored vehicles assigned to combat units are maintained in a simulated theater maintenance loop to repair combat and breakdown damage. This loop represents all maintenance above division level. It is controlled by three input characteristics: proportion repaired, repair capacity, and repair time for each type of major weapon. Excess requirements for maintenance queue up and repaired weapons are assigned to the appropriate theater distribution pool. The theater maintenance policies such as level of maintenance to be performed in theater, location of maintenance facilities, and number of maintenance units assigned, determine the proportion of these three characteristics. Theater repair capacity can vary over time and on the Blue side among nationalities according to input specifications.

c. Transportation Support. Transportation is considered to be a service function that has a capacity and movement rate for the five categories of supply. The capacity is a constraint that must be exercised outside the CEM.* The movement rates (and handling times) are simulated by input time delays which are imposed between the time items arrive in the theater and the time they are included in the theater pools. These delays are a function of the state of friendly air environment.**

d. Personnel Support. A theater personnel loop, similar to the maintenance loop, is simulated in the theater to represent the ability of the general hospital system to return wounded and injured combat personnel to combat duty. The number of patients returned to duty and their time in theater hospitals is determined by the theater evacuation policy. The returned-to-duty patients are entered into the personnel theater distribution pool along with replacements from out of theater for assignment back to combat units.

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*See Resupply Rates in Part II.

**See para 7-2f, Armed Reconnaissance and Interdiction.

CHAPTER 3

ARMY CYCLE

3-1. ARMY DECISIONS

a. Within the constraints of the theater allocation of any new reinforcing divisions and CAS allocation to the field armies, the armies then assign divisions to their subordinate corps and make their mission decisions and fire support allocations to their subordinate corps each army cycle. Each field army thus makes a mission selection and decides whether to retain or reconstitute a reserve corps by comparing an estimated friendly-to-enemy force ratio to army mission thresholds. An army that has selected either a defend or delay mission realigns its corps boundaries in an attempt to frustrate the attacker's attempt to gain local superiority. Although the army may have no field artillery as such, it nevertheless can shift corps artillery from one corps to another. It does this by combining artillery from all its subordinate corps and reallocating it among the corps at the beginning of each army period.

b. The sequence of army decisions is as follows:

(1) Assigning reinforcing divisions (and Red rebuilt divisions) to armies.

(2) Assigning army reserve pool divisions to corps.

(3) Mission selection.

(4) Reserve corps commitment or reconstitution.

(5) Realignment of corps frontages (if army is not attacking).

(6) Allocation of fire support to corps (artillery and CAS).

3-2. ASSIGNING REINFORCING DIVISIONS

a. Each army headquarters maintains a pool of reserve divisions. The maximum number of divisions allowed in each army's pool is specified by input (or set to zero if this feature is not wanted). Divisions leave the army reserve pools according to rules to be described below. A division can enter an army reserve pool if: (1) it is in reserve to a subordinate corps with no commitment plan at the end of an army cycle; (2) it arrives in

theater as a reinforcing division; (3) it has been rebuilt in the Red theater rebuilding pool; or (4) a Blue weak on-line division within the army sector is exchanged for a division in the reserve pool. The CEM user specifies the army period in which each reinforcing division will become effective. He may opt to allow the model rules to select the army to be reinforced, or he may designate the army within which a corps will be selected (by model rules) for reinforcement. The first step in the assignment of an arriving reinforcing division is to place the division in the reserve pool of a field army. If an army has not been designated by input or if the reserve pool of the designated army is full, the army will be selected which has the subordinate corps considered optimal for reinforcement according to the following criteria.

(1) Corps on delay are given first priority for reinforcement. If there are any corps on delay, the army is selected which includes the delaying corps with the lowest estimated friendly-to-enemy force ratio (CRIFP).* Second priority is given to corps on attack. If no corps is on delay, then the army is selected which includes the attacking corps that has the highest CRIFP. If there are no corps on delay or attack, then the army is selected which includes the corps that has the lowest CRIFP.

(2) In this selection process, those armies having a full reserve pool are eliminated from consideration. If all army reserve pools already contain the maximum number of divisions specified by input, the reinforcing division is assigned directly to the optimal corps.

b. Prior to completing the division assignment process, if weak on-line division replacement is requested by input, the on-line divisions in each Blue army are scanned for candidates to be replaced. The criteria for a candidate division are that the division's enemy-to-friendly force ratio exceeds an input threshold and that the division's frontage exceeds the minimum Blue division frontage by no more than one minisector. If a candidate weak on-line division is found within a Blue army, the strongest division in this army's reserve pool (if any) is compared with the weakest on-line candidate for replacement. If the ratio of the strength of the strongest reserve pool division to the strength of the weakest candidate exceeds an input threshold, the two divisions are flagged to be exchanged after an input delay, and the comparison is repeated with the next strongest reserve pool division and

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*For method of estimating enemy force, see Mission Selection and Reserve Considerations, para 3-4.

the next weakest on-line candidate, until the army's reserve pool or list of candidates is exhausted. (In this context the "strength" of a division means the product of its state and its authorized meeting engagement firepower.)

c. The next step in assigning divisions is for each army headquarters to assign divisions from its reserve pool to its subordinate corps. If there is at least one division in an army reserve pool, and that army has at least one subordinate corps with sufficient frontage to commit another division, then the strongest division in the army reserve pool will be assigned to a subordinate corps as corps reserve, with the recipient corps selected according to the following priorities. Corps on delay previous period are given first priority. If there are any subordinate corps on delay, the division is assigned to the one that has the lowest CRIFP. Second priority is given to corps on attack. If no corps is on delay, then the division is assigned to the attacking corps most likely to commit a reserve division. If there are no corps on delay, and no corps on attack that are likely to commit a reserve (based on the previous corps cycle estimation), then the division is assigned to the defending subordinate corps that has the lowest CRIFP. This process is repeated until either the army reserve pool is exhausted or the suitable subordinate corps each have a division in reserve. No corps with a division already in reserve, or with insufficient frontage to commit another division, can receive a division from the reserve pool.

(1) If the addition of the assigned division results in a corps of no more than five divisions, the newly assigned division becomes the corps reserve. If the addition would result in a corps of six divisions, then two corps are created from the old corps. The northernmost three divisions comprise the original corps. If sufficient frontage remains, the other two divisions plus the reinforcing division comprise the new corps. Otherwise, the reinforcing division is assigned to the original corps.

(2) If the creation of a new corps would result in an army of six corps, then two three-corps armies are created from the old army. GS artillery battalions and CAS sorties available to the old army are divided between the two armies in proportion to the number of divisions in the subordinate corps. The divisions remaining in the original army reserve pool are divided evenly between the two armies, unless one or the other army has insufficient frontage.

(3) However, if the assignment of a division to a particular corps would result in the creation of a new army from an army with fewer than 18 divisions in its subordinate corps and fewer than 21

divisions including the reserve pool, that corps is excluded as a candidate parent for the division. This reduces the likelihood of a proliferation of new army headquarters.

d. The rules for assignment of reinforcing divisions apply also to divisions that have entered the army reserve pools from corps reserve, from the Red decimation pool,* and by Blue weak on-line division replacement. As mentioned above, any division that remains in corps reserve without a commitment plan at the end of an army cycle is removed from the corps. On the Blue side, and on the Red side if the rebuilding (decimation) pool is not in operation or is filled, this division is placed in the reserve pool of its parent army. A Blue on-line division can also enter its parent army reserve pool if the weak on-line division replacement logic exchanges it for a (stronger) division from the army reserve pool. Divisions can leave the reserve pool of an army only by being assigned to a subordinate corps of that army or, on the Blue side, by exchanging places with a weakened on-line division within that army sector.

3-3. ARMY ESTIMATED FORCE RATIO

a. The army mission and other decisions are based on a set of estimated force ratios, ARIFP. Different ratios are estimated, depending on (1) what mission the army is considering, and (2) decisions regarding reserve status.

b. Each ARIFP is a friendly-to-enemy force ratio in which known forces are used for the friendly side and estimates based on intelligence of the recent past are used for the enemy. In determining which mission to undertake, the friendly force is the sum of the force (modified meeting-engagement index of firepower potential (IFP)) for all subordinate corps. Each corps' force is the sum of: (1) the full strength IFP** of all maneuver battalions capable of the army mission multiplied by their respective states, (2) the current number of helicopters in the corps and division cavalry units (Blue only) multiplied by the sum of the respective corps and division per helicopter IFP array, and (3) the

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*For a discussion of rebuilt divisions and the decimation pool, see para 4-2, Red Division Replacement.

**The IFPs that are used for army-level and corps-level decisions are full strength meeting engagement IFPs. It should be kept in mind, however, that ARIFP has different values in considering different missions because some battalions are capable of undertaking one mission but not another.

sum of the IFP values for each of the divisional artillery battalions (within each corps). When considering reserve status, the friendly force is calculated as above, but excluding the reserve corps, or if there is none, the one with the lowest IFP. The estimated enemy force from the army history array for each of the two appropriate army cycles is weighted by intelligence factors and includes the above three components of force* as they existed when placed in the history arrays plus any nondivisional GS artillery that was employed in the DS role.

3-4. MISSION SELECTION AND RESERVE CONSIDERATIONS. The army first considers an attack mission, and, if this is unacceptable, then it considers defense. If the ARIFP is too small for the defend mission, then the army accepts the delay mission. Having decided on a mission, the army decides whether to reconstitute a reserve (assuming it has been committed earlier) or whether to commit a reserve. It cannot do both in the same period. The decisions are made through comparison of the force ratios (developed in the preceding section) with certain mission thresholds.

a. Attack

(1) For the attack mission the thresholds are:

AAT_1 = army attack mission threshold, below which the army should not undertake an attack;

AAT_2 = army attack-with-reserve threshold, above which a corps is kept in reserve.

(2) The army first estimates the army force ratio, ARIFP, as follows. On the friendly side all units that are in corps on line and capable of undertaking the attack mission are identified, and their forces are added to the forces of all corps and line division artillery battalions.

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*If the army is considering an attack mission and hence including only those battalions capable of attacking on the friendly side, then for the enemy force calculation only those maneuver battalions capable of defense are included. If the corps is considering a defense or delay mission, only the enemy battalions capable of attack are included in the estimated enemy force. On the enemy side the units that are in line corps facing the army and capable of undertaking the complementary mission of defense are estimated and their forces are added to the forces of all artillery battalions estimated to be facing the army (as developed in the preceding section).

(a) First the ARIFP is calculated including all the subordinate corps of the friendly army. This ARIFP is used for comparison with AAT_1. If ARIFP exceeds AAT_1, the army mission becomes attack; otherwise, a defense mission is considered.

(b) If ARIFP exceeds AAT_1, then a new friendly-to-enemy force ratio is computed for comparison with threshold AAT_2. This second ARIFP is similar to the first, except that the army's reserve corps is excluded from the army force ratio. If there is no reserve corps, the value of the army's weakest (in terms of the previously defined CRIFP) corps is not included in the friendly force.

1. If ARIFP is greater than AAT_2,* the army assumes an attack mission with a reserve. If there was not a reserve, then one is created by withdrawing the weakest on-line corps. The gap thus created is filled by extending the adjacent corps having the greater CRIFP.

2. If ARIFP is less than AAT_2, the army assumes an attack mission without a reserve. The army reserve (if one exists) takes over a portion of the frontage held by the on-line corps with the greatest CRIFP, thus supporting strength in the attack.**

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*The rationale for army decisions (as well as for corps and division decisions) is to determine the best result that can be expected, and then allocate the least resources necessary to achieve that result. If the army can reconstitute a reserve and still expect to attack successfully, it should do so. On the other hand, if it cannot expect to attack successfully even after committing its reserve, it should neither attack nor commit its reserve. If the success of an attack without reserve commitment is in doubt, then the army should commit its reserve and attack.

**If the frontage of the on-line corps is so narrow as defined by the input minimum division frontage that it cannot accept the total number of divisions within the on-line corps and in the reserve corps (i.e., $F_c < nm$ where F_c = number of minisectors in the on-line corps frontage, m = number of minisectors in the minimum division frontage, and n = number of divisions in the two corps), then the reserve corps supports the corps with the next highest CRIFP, etc. In the event that no on-line corps is supportable in this fashion, then the corps boundaries are realigned to allow commitment of the reserve.

b. Defend. In the two cases above, ARIFP is greater than AAT_1 and the army mission becomes attack. If ARIFP is less than AAT_1, then a defense mission is considered. In considering a defense mission, the steps described above for attack are followed, except that the defense thresholds, ADT_1 and ADT_2, are used, and reserve commitment is positioned to support the weakest division.

c. Delay. If ARIFP is less than ADT_1, then the delay mission is assumed and reserve commitment considered in a similar fashion. This complete sequence leads to an army mission and a decision on reserve commitment or reconstitution.

d. Reserve Decision Implementation

(1) When a reserve is reconstituted, it leaves the line with no time delay and the divisions within the expanding corps (filling the gap) receive new frontages that are proportional to the frontages they had before the expansion.

(2) Commitment of the army reserve is delayed by integral numbers (depending on the air environment) of corps periods after the decision. When the reserve corps is moved onto the line, thus taking over a portion of the supported corps frontage, the split in frontage is in proportion to the number of divisions in the two corps.

3-5. DECISION ON CORPS BOUNDARIES

a. If the army decides to attack, then the corps boundaries do not change unless a corps is being reconstituted, in which case one of the adjacent corps widens its frontage to cover the gap. If the decision is made to commit a reserve corps, then the boundaries will change later as the reserve moves into line as described in the previous section.

b. If the army decides not to attack, but to defend or delay, then the army is allowed to readjust the subordinate corps boundaries in an attempt to "even out" the force ratio across the army front thereby making it more difficult for an opposing attacker to gain local superiority. The adjustment of boundaries is based on the estimated force density of the enemy and on the known force density of friendly forces, and the resulting adjustment or shifting of corps boundaries is constrained by a maximum allowable shift (input data).

c. The force values that are used for this calculation are those used for the army mission selection. That is, on the enemy side an attack force density per minisector is calculated from the

history arrays of the two appropriate army cycles with the weighted intelligence factors to arrive at an estimated enemy density. The force thus calculated includes weighted portions from the erstwhile strength (from the appropriate army cycle) of all maneuver battalions (or regiments) capable of attack, of all cavalry units (if the enemy be Blue) and all division and nondivision artillery from the on-line corps in the appropriate army cycles. On the friendly side, a defending (or delaying if that be the army mission selection) force sum is calculated for each subordinate corps, including the current strength of all maneuver battalions (or regiments) capable of the army mission, the current strength of the cavalry units (if the friendly side be Blue), and all artillery.

d. The estimated enemy force density and the friendly force values of the several subordinate on-line corps are used to determine the new minisector boundaries that would give each corps an equal slice of estimated enemy strength to defend against. Then if the shifting of the current corps boundaries to the desired locations does not exceed maximum allowable corps boundary shift, the boundaries are so moved. If any such shift is too large, then that boundary shift is limited to the maximum allowed. In any case, the boundaries of the on-line divisions within each corps are shifted so that each division retains the percentage of corps frontage that it had prior to the boundary shift.*

3-6. ALLOCATION OF FIRE SUPPORT. The army combines the artillery from all its subordinate corps and allocates it among the corps at the beginning of each army period (after the other army decisions have been made). The allocation is made to support strength on offense and weakness on defense. For each corps on-line, the CRIFP is calculated: friendly-to-enemy CRIFP if the army has an attack mission, otherwise enemy-to-friendly CRIFP. Next the artillery units available for allocation are converted into a number of composite artillery battalions. Finally, the composite battalions are allocated among the corps on-line in proportion to CRIFP/ΣCRIFP, where the sum is taken over all corps in the army and on line.

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*If the desired boundaries result in any one corps being below the allowable frontage for that corps, then no boundary adjustment is made for any corps within this army period. CAS sorties are allocated in the same way as artillery battalions.

CHAPTER 4

CORPS CYCLE

4-1. GENERAL. The corps makes the same types of decisions as the army in essentially the same way. Like the army, the corps makes a mission selection and decides whether to retain or reconstitute a reserve by comparing an estimated friendly-to-enemy force ratio to corps mission thresholds. A corps that has selected either a defend or delay mission realigns its corps boundaries in an attempt to frustrate the attacker's attempt to gain local superiority; however, the basis for this realignment is slightly different than it is for the army. The sequence of corps decisions that are based on force ratios is:

a. Mission selection.

b. Reserve commitment or reconstitution.

c. Realignment of division frontages (if corps is not attacking).

d. Allocation of fire support to divisions (artillery, cavalry, and CAS).

The estimates and decisions will be described in the order in which they occur in the CEM, but preceding this, a description is given of Red division replacement, which occurs before the estimates and above mentioned decisions.

4-2. RED DIVISION REPLACEMENT

a. In order to be capable of playing a Red doctrine of echelonment and depletion of on-line divisions while previously exhausted divisions are being rebuilt, the CEM has the following special rules for Red at the corps level (Red army level) which do not apply to Blue. This logic allows the Red on-line divisions to become decimated without receiving replacement personnel and major weapons, while such replacement is going to previously decimated divisions to rebuild them.

b. At the beginning of the corps cycle, the state of each on-line and reserve Red division is compared against a critical threshold, which has one value if the corps mission is attack and another value if the corps mission is defense or delay. If the state is below this threshold, and there are currently at least two divisions belonging to the parent Red army, then the "decimated" division is transferred (away from the front) to a

decimation file and the frontage of an adjacent on-line division is expanded to occupy the gap in accordance with the rules that apply to reserve reconstitution. The decimated division is tagged for return to the same parent army after rebuilding and after a minimum duration in the decimation file. The division is considered rebuilt with replacement personnel, major weapons, and resupply when its state exceeds a given threshold and the minimum time has elapsed. It is then transferred to the reinforcing file for the appropriate army (to be returned to the front in the subsequent army cycle).* A decimated Red division which has not been rebuilt to this threshold state after a specified time (input value) is stripped of all its assets (cannibalized) and denied further resupply and replacements. The assets from cannibalized divisions are used to rebuild other divisions. At a specified time (input value) in the simulation, this "unit replacement" policy can be ceased; thereafter no on-line Red divisions are transferred to the decimation file, and resupply and replacements go to on-line divisions as well as to those in the decimation file.

4-3. CORPS ESTIMATED RATIO

a. The corps mission and other decisions are based on a set of estimated force ratios, CRIFP. One estimated ratio is used when the corps is considering an attack mission, another is used for considering defense, and still another if the corps decides it must delay during the ensuing corps period.

b. Each CRIFP is a friendly-to-enemy force ratio in which known values are used for the friendly side and estimates based on intelligence of the recent past are used for the enemy. In determining the corps mission, the friendly force includes all subordinate divisions. In deciding whether to commit or reconstitute a reserve, the friendly force is the sum of the forces for all but one subordinate division (excluding the reserve or, if there is none, the one with lowest force). Each division's force is the sum of: (1) the full-strength IFP of all maneuver battalions capable of the corps mission multiplied by their respective states, (2) the current number of helicopters in the division cavalry unit (Blue only) multiplied by the sum of the division per helicopter IFP matrix, and (3) the sum of the IFP values for each of the divisional artillery battalions. The estimated enemy force from the

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*For rules governing the return of the rebuilt division to a location along the front, see para 3-2, Assigning Reinforcing Divisions.

corps history arrays of the two appropriate corps cycles is weighted by intelligence factors and includes the above three components of force* as they existed when placed in the history arrays plus any nondivisional GS artillery that was employed in the DS role.

4-4. MISSION ASSIGNMENT AND RESERVE CONSIDERATIONS

a. The corps first considers an attack mission, and, if this is unacceptable, then it considers defense. If that is also unacceptable, then it accepts the delay mission. Having decided on a mission, the corps decides whether to reconstitute a reserve (assuming it has been committed earlier) and whether to commit a reserve. It cannot do both in the same period. The decisions are made through comparison of the force ratios with corps mission thresholds. For the attack mission these thresholds are:

CAT_1 = lower corps attack threshold, below which the corps should not undertake an attack;

CAT_2 = corps attack-with-reserve threshold, above which a division is kept in reserve.

b. The corps first estimates the corps force ratio, CRIFP, as follows. On the friendly side, all units that are in divisions on-line and capable of undertaking the attack mission are identified, and their forces are added to the forces of all corps and line division artillery battalions. On the enemy side the units that are in line divisions facing the corps and capable of undertaking the complementary mission of defense are estimated and their forces are added to the forces of all artillery battalions estimated to be facing the corps.

c. First the CRIFP is calculated including all the subordinate divisions of the friendly corps. This CRIFP is used for comparison with threshold (input data) CAT_1. If CRIFP exceeds CAT_1, the corps mission becomes attack; otherwise, a defense mission is considered.

d. If CRIFP exceeds CAT_1, then a new friendly-to-enemy force ratio (CRIFP) is computed for comparison with the threshold CAT_2.

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*If the corps is considering an attack mission and hence including only those battalions capable of attacking on the friendly side, then for the enemy calculation only those maneuver battalions capable of defense are included. If the corps is considering a defense or delay mission, only the enemy battalions capable of attack are included in the estimated enemy force.

This second CRIFP is similar to the first, except that the corps reserve division is excluded from the corps force ratio. If there is no reserve division, the value of the corps' weakest division is not included.

(1) If CRIFP is greater than CAT_2, the corps assumes an attack mission with a reserve. If there is no reserve, then one is created by withdrawing the weakest on-line division. The gap thus created is filled by extending the adjacent division having the greater division friendly-to-enemy force ratio (DRIFP).

(2) If CRIFP is less than CAT_2, the corps assumes an attack mission without a reserve. The corps reserve (if one exists) takes over half the frontage held by the on-line division with the greatest DRIFP, thus supporting strength in the attack.*

e. In the two cases above, CRIFP is greater than CAT_1, and the corps mission becomes attack. If CRIFP is less than CAT_1, then a defense mission is considered. In considering a defense mission, the steps described above for attack are followed, except that the defense thresholds, CDT_1 and CDT_2, are used, and reserve commitment is positioned to support the weakest division. It should be kept in mind, however, that CRIFP has different values in considering different missions, because some battalions are capable of undertaking one mission but not another.

f. If CRIFP is less than CDT_1, then the delay mission is assumed and reserve commitment considered in a similar fashion. This complete sequence leads to a corps mission and a decision on reserve commitment or reconstitution.

g. Actual commitment of the reserve division is delayed by an integral number of division periods after the decision, but there is no delay in implementing other tactical decisions at corps level. The extent of the delay in reserve commitment depends on whether a friendly air environment exists; i.e., on the level of enemy interdiction, armed reconnaissance, and counterair activity.

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*If the frontage of the on-line division is so narrow as defined by the input minimum division frontage that it cannot accept two divisions therein, the reserve division takes over half the frontage held by the on-line division with the next highest DRIFP, etc. In the event that no on-line division is supportable in this fashion, then the division boundaries are realigned to allow commitment of the reserve.

4-5. REALIGNMENT OF DIVISION FRONTAGES

a. A defending or delaying corps adjusts its division boundaries in an effort to "even out" the threat against it and in an effort to reduce any salients into its region or penetrations along its flank.

b. The methodology is as follows. An estimated enemy force density is taken from the history arrays just as it is for the mission decision and is arranged into an estimated force per minisector, I_m (see Figure 4-1). Then the distance d_m (see Figure 4-2) of FEBA location of each minisector from the forwardmost FEBA location of the corps frontage is taken. The function,

$$F_m = \sqrt{I_m(1 + d_m)}$$

is used to adjust the division boundaries. First, the friendly division force of each on-line division as calculated for the corps mission decision is determined. The ratio of each division force to the sum of the force values for the corps' on-line divisions is computed. Second, the values of function F_m are summed for each minisector across the corps front and the ratio of each minisector value to the sum of values is determined. Then, the number of minisectors that would give each division a proportionate share of the function is determined. For example, if division X had 25 percent of the corps force, then division X boundaries would be adjusted so that the division would oppose 25 percent of F in front of the corps. If the shift of any division boundary from its current location to the desired location is greater than a maximum allowable shift (input value), it is constrained by the latter. (Also no division is allowed to have a frontage that is less than the minimum allowable division frontage.)* Otherwise, the division boundaries are shifted to the desired locations with no time delay. If the defending corps is Blue, the division boundary shifts are accompanied by subordinate on-line brigade boundary shifts that divide the amount of change in a division's frontage equally among the on-line brigades within the division, which may then be further modified during division assignment of brigade missions.

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*An additional constraint on the division boundary shifts is the following. If the number of minisectors across the corps frontage is less than n(m+2), where m = minimum division frontage and n = number of divisions with the corps, then no adjustment is made during the current corps cycle.

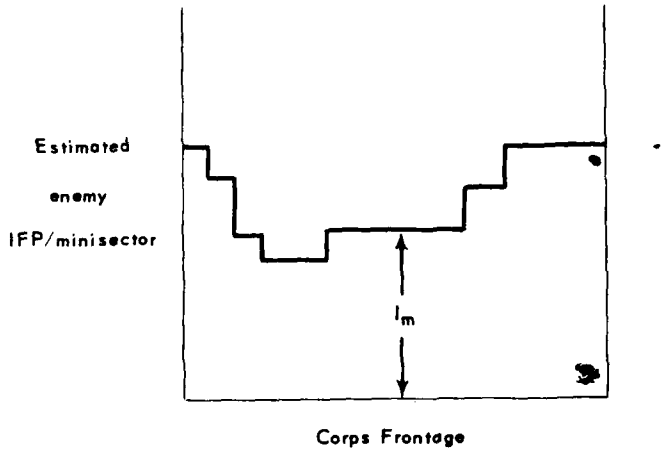

Figure 4-1. Distribution of Estimated Enemy IFP Across Corps Front

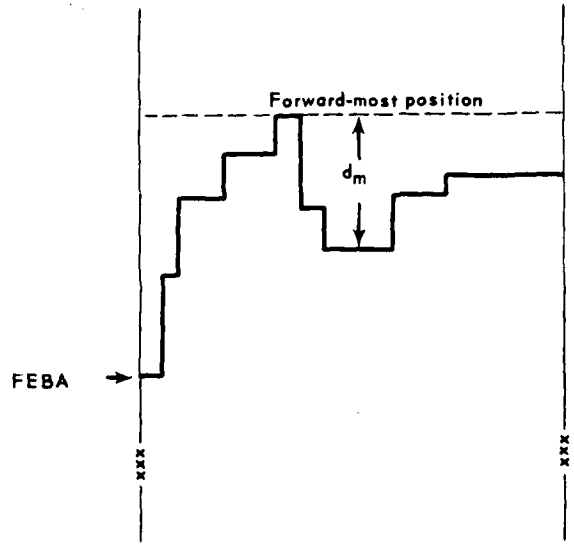

Figure 4-2. Distribution of Enemy's Penetrations Measured from Defender's Forwardmost Position

4-6. FIRE SUPPORT ALLOCATION

a. All corps artillery and reserve division artillery is employed in support of divisions on-line and none is held in reserve. A fraction of corps artillery and reserve division artillery may be assigned by division to provide reinforcing fire in direct support of brigades on line (see Chapter 6, Division Cycle). Artillery battalions so employed are counted in determining the outcome of brigade engagements and in the assessment of enemy casualties and losses. Any remaining unconverted corps and division GS artillery battalions are used to neutralize enemy DS artillery fires and to engage reserve divisions, inflicting enemy casualties and losses.*

b. The reserve division artillery remains under corps control for allocation to the on-line divisions until such time as the reserve division, after having been committed, arrives on the FEBA. At that time, at the beginning of an intermediate division cycle, the division artillery is returned to the division and a reallocation of corps artillery among the divisions is performed.

c. In general, corps artillery is allocated so as to support strength of offense and weakness on defense. For each division on line, the division force ratio (DRIFP) is calculated: friendly-to-enemy DRIFP if the corps has an attack mission, otherwise enemy-to-friendly DRIFP. Next the corps artillery units available for allocation are converted into a number of equivalent artillery battalions. Finally, the equivalent battalions are allocated among divisions on line in proportion to $DRIFP/\Sigma DRIFP$, where the sum is taken over all divisions in the corps and on line.

d. The corps cavalry unit and CAS sorties are allocated in the same proportions as equivalent artillery battalions.

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*Three additional effects of GS artillery are worth mentioning; slow down of: (a) movement of enemy supplies and replacements, (b) movement of enemy reserve units, and (c) rate of enemy artillery fire. The model makes use of fixed delays for (a) and (b) and specified rates of fire (depending on the situation) for (c), all of which are assumed to include average effects of GS artillery and tac air.

e. Red reserve division organic artillery:

(1) A special case of Red reserve division allocation is provided to permit the user to specify whether Red reserve divisions retain their organic artillery battalions in reserve with them and not employ it, or release the artillery to engage enemy reserve units in a GS role.

(2) A switch is provided to permit the user to specify whether Red reserve division organic artillery battalions are to be employed against Blue reserve units or are to be retained in reserve with the parent division during the corps cycle. If the switch is OFF (an input value), the reserve division organic artillery remains with the division and is not employed. If the switch is ON, the Red reserve division organic artillery battalions are added to the remaining GS artillery battalions across the front and engage Blue reserve units. If the reserve division is moved on line, its organic artillery battalions are returned to it and are employed in the normal manner.

4-7. RECAPITULATION OF HIGHER LEVEL DECISIONS

a. The corps- and army-level decisions have resulted in the allocation of resources to subordinate commands in accordance with the parental mission. Subordinate boundaries have been addressed and altered where necessary. The status of reserves has been determined down to the division level. Thus all divisions have either been assigned specific locations on the line or in reserve and resources have been allocated among them from the higher echelons.

b. The division-level decisions represent the final decision process within the CEM and therefore are the most complex. Hypothetical engagement situations are postulated and addressed within the division cycle. Thus the decisions at this level are more easily understood if one is familiar with the engagement parameters. For this reason the description in terms of the normal sequence of events will be altered at this time in order to acquaint the reader with the engagement process. The remaining occurrences within the division cycle will then follow the engagement presentation.

CHAPTER 5

ENGAGEMENTS

5-1. GENERAL. As stated earlier, the presentation in terms of the normal sequence of events is disrupted at this point to acquaint the reader with the engagement process, after which the division-level decisions that are based upon it will be presented.

5-2. CHARACTERISTICS OF ENGAGEMENT. Generally speaking, combat action is resolved to brigade level and the brigade-level engagement is an aggregated summary of the combat activities occurring in a (brigade) sector during a division period. An engagement is characterized by (a) the composition of the engaged forces, (b) the type of engagement, and (c) the type of terrain. These will be discussed in turn.

a. Engaged Forces

(1) The Blue forces include the brigades, division cavalry units, corps cavalry units, DS artillery battalions and tactical aircraft. The Red forces are the maneuver elements of the division, supported by DS artillery battalions and tactical aircraft. As discussed earlier, the number of maneuver battalion (and regiment) types and supporting artillery coupled with the latitude in status file description is sufficient to simulate any credible force. Fire support from tactical aircraft (CAS) is played as a function of the number of aircraft sorties available.

(2) All combat personnel and major weapons in the sector are considered to be engaged as are all supporting elements.*

b. Type of Engagement. The type of engagement is determined by the missions of the opposing forces and, where appropriate, the type of defensive position. Allowable missions, position types, and the corresponding engagement types are summarized in Table 5-1. Note that there are three possible missions (for each side), two types of defensive positions, and eight possible types of engagements.

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*The expenditure of artillery ammunition can be at one of two levels. The decision on the level employed is made by the division commander in the estimate of the situation.

Table 5-1. Missions, Types of Position, and Types of Engagement

Red Mission / Red position type / Blue mission / Blue position type		Attack	Defend		Delay
Blue mission	Blue position type	--	Prepared	Hasty	--
Attack	--	Meeting engagement	Blue attack of prepared position	Blue attack of hasty position	Blue advance
Defend	Prepared	Red attack of prepared position	Static	Static	Static
	Hasty	Red attack of hasty position	Static	Static	Static
Delay	--	Red advance	Static	Static	Static

c. Defensive Positions. The two types of defensive positions are not placed on the terrain in advance of the play. Instead, they are simulated dynamically, reflecting the time to prepare the positions and taking into account the type of equipment that is employed in making such preparations. The time for behind-the-lines position preparation is adequate only if the front line is stable or the FEBA is moving at a fairly slow rate. Thus the existence or nonexistence of prepared positions is represented in the CEM as a function of the rate of FEBA movement. For a given rate of FEBA movement, one type of division may have the capability to complete a prepared defense whereas another type of division may not. The CEM accommodates this differing capability for Blue. The type of Blue defensive position that is played in one division cycle is dependent on how fast the FEBA has been moving in the recent past and on which division is there to construct the position.

(1) The manner in which the CEM averages recent FEBA movement rate is called exponential smoothing; it is essentially a time-average rate calculation with the capability of weighting the more recent past. The averaging is performed on a minisector

basis and records are retained by minisector. As it becomes necessary to identify whether or not a prepared position has been constructed for a given subsector engagement, the rates of FEBA movement for the several minisectors in that subsector are averaged and matched against a threshold rate value to determine whether the FEBA has been moving slowly enough for a prepared position to have been constructed. There is only one threshold rate value against which the average FEBA movement rate can be compared for Red, but, for Blue, there is a threshold rate value for each division. The process of exponential smoothing as applied to the FEBA movement rate is rigorously defined as follows.

(2) Let the minisectors in a defensive sector front be identified as 1 thru m, and let the distance of FEBA movement in the n^{th} division period for each minisector in the sector be d_{jn} where $j=1,\ldots,m$. Furthermore, let r_{jn-1} be the exponentially smoothed time average of the FEBA movement in the j^{th} minisector up to, but not including, the n^{th} period. Then the exponentially smoothed time average of the FEBA movement at the n^{th} period in the j^{th} minisector is found by

$$r_{jn} = (1 - w)r_{jn-1} + wd_{jn}$$

where w is the time average weighting coefficient, the value of which may range from zero to one. The average FEBA movement over the sector is given by:

$$R = \frac{1}{m} \sum_{j=1}^{m} r_{jn}$$

Then if R is less than D (the threshold rate value), the defending brigade has had time to construct a prepared position.* At the beginning of a war, $r_{jo} = 0$.

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*A unit that goes on defense after several periods of successful attack generally will not have prepared positions immediately available. This explains why the absolute value sign is used in the inequality. Thus there is only one value of D which is used for all Red division types.

(3) Blue Division Defending. It was previously mentioned that the threshold value, D, against which the FEBA movement rate is compared is itself dependent on the Blue division defending the frontage. Blue divisions are categorized by their capabilities to construct prepared defense and/or barriers. Red divisions are not so categorized since the battles are expected to take a Red-attack Blue-defense posture generally.

(4) Other effects of the barriers and prepared defenses are: (1) modification of firepower with the resultant change in losses and (2) the lessened advance made by the attacker across the barrier. These latter effects are discussed below in para 5-3 and para 5-4h.

d. Selection of Terrain Type. In most cases the terrain across a subsector front will be all of one type. Occasionally, however, more than one type may be present. When this occurs, the terrain type to be used for determining the engagement outcome is found in the following manner. If terrain type D is at the lowest numbered minisector of the subsector front, then terrain type D is used. If not, terrain type D is not used, and the following rules apply. If at least one-third of the minisectors in the subsector front are type A, then type A is used. If the subsector front contains at least a third of the combination of types A and B, then type B is used in determining the engagement outcome. If none of the above conditions is met, then type C is used.

5-3. EFFECTIVE FIREPOWER DEVELOPMENT

a. Employment. Effective firepower is developed for employment against the opponents in each subsector along the FEBA. Additional indirect firepower that is not so employed is directed against Blue reserve brigades and Red reserve divisions.

b. Factors Involved. The firepower that is employed in each subsector engagement will be discussed first; it is dependent on the type of engagement, the numbers and types of weapons, the amount of supply on hand, and on the type of terrain. At this point in time the two opposing forces have selected their missions; hence the type of engagement is determined. The type of terrain is determined by its location, and the forces include the following. On the Red side, the maneuver elements of a division (or portion thereof) are represented by the men, materiel, and supplies that are currently recorded in that division's status file. Augmenting the force represented in the division status file are the forces in the artillery battalion status files firing in DS and a number of CAS sorties. On the Blue side, a brigade (or portion thereof) is represented by the men, materiel, and

supplies that are currently in the brigade status file. Augmenting the force represented in the brigade status file are forces represented by the division cavalry status file, part of which is to support his brigade. Also augmenting these forces are forces represented by a portion of the corps cavalry status file and the DS artillery battalion status files, along with a number of CAS sorties.

c. Unit Firepower

(1) The amount of firepower that each maneuver unit and artillery battalion will bring to bear on the enemy is determined and categorized to produce casualties, weapon losses, and FEBA movement.

(2) The firepower from each status file is determined as follows. For each major weapon type (and for personnel) found in the status file, three per weapon firepower scores (input numbers) representing the antitank (AT), antilight armor (ALA) and antipersonnel (AP) firepower for the current engagement type are multiplied by the current number of weapons (or men in the case of personnel) of that type in the status file.

d. Flank Defense. During the engagement assessment, a portion of the force is placed on the flanks of each subsector irrespective of mission, thus leaving a lesser force along the front to engage the enemy. The firepower from the weapons that remain along the front of the subsector is instrumental in determining the engagement outcome; the firepower along the flanks is not. The proportion of firepower that remains along the front is determined as follows. For a subsector whose breadth of front is m minisectors and whose combined flank length on both sides of the subsector is h hectometers, the proportion, p, of firepower that is employed across the front is:

$$p = \frac{m}{m + k\ h}$$

where k is an input value employed for both sides. In the assessment of FEBA movement, the firepower that remains along the front on one side is compared with that remaining along the front from the other side.

e. Firepower Constraints. The application of expected firepower may be constrained due to shortages in supplies and (in the case of artillery battalions) supporting personnel. An additional constraint may be applied to the employment of helicopters in cases of strong enemy air defense. Finally, the effects from DS artillery battalions may be constrained because of a lack of complete coordination with the supported maneuver units. These constraints are discussed in detail in the following paragraphs.

(1) Firepower constrained by supply:

(a) Supplies in the CEM are categorized as POL, ammunition, and other. In each maneuver unit's status file is kept a record of the amount of each class of supply on hand, and as new supplies arrive they are added in. (No supply record is maintained for those elements that have no status file, i.e., tactical aircraft.) In each engagement the three classes of supply are expended by the types of maneuver units having status files: the Red division, Blue brigade, Blue division cavalry unit, and Blue corps cavalry unit. Artillery battalions are a special case in that they expend ammunition only. The manner in which the expenditure is calculated is the same for the three types of supply and for each unit. The procedure will be given here in terms of ammunition. (In those cases where the engagement involves only a portion of the unit's frontage, the amounts are prorated accordingly.) First, the amount of ammunition to be fired normally in this type of engagement is summed over all current major weapons and personnel in the status file and is compared with the amount of ammunition on hand. If there is ample ammunition so that no conservation need be considered, then the number of tons in the present sum becomes the amount of ammunition expended by the unit in the engagement. However, if the amount to be expended is "too close" to the amount on hand, then conservation measures will be applied, and this conservation will have a bearing on the amount of firepower employed during the engagement. The amount to be expended, e, is defined to be "too close" to the amount on hand, h, when $h/n < e$, where n is an input number (for the type of supply) that represents a safety level for the unit stocks. Whenever this occurs, the amount to be expended is reduced to h/n. The dimensions of e, h and n are tons per division cycle, tons, and division cycles, respectively.

(b) If supply conservation was found to be necessary for any of the three types of supply, then the three firepower values just calculated for each weapon type and/or for personnel are modified. One method of modification is used for helicopters; another is used for the other types of major weapons, artillery, and for personnel found in each status file. For the latter the

following is done. For each supply category that was conserved, a firepower modifier (ranging from zero to one) is multiplied by each of the three firepower values to arrive at new modified firepower scores. The firepower modifier is determined by two input numbers for each type of supply and each major weapon. The two input numbers are shown in Figure 5-1 and are labeled P and Q. The abscissa in the figure represents h/ne, the fraction of normal supply consumed for the current type of engagement. The point, Q, gives the value of h/ne below which reduced consumption has an effect on the firepower. The point, P, gives the fraction of the firepower that is still functional when consumption goes to zero. When h/ne has the value, x, as in the figure, then the firepower modifier takes on the value y. In the special case of ammunition shortage, P is set to zero and Q is set to 1, but for POL and other supply shortages, P and Q may have any value between zero and one. When all three types of supply are conserved in an engagement, then the product of the three separate firepower modifiers is multiplied by the IFP scores.*

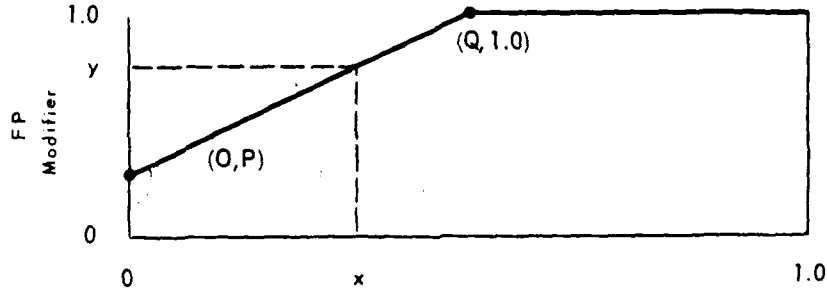

Figure 5-1. Fraction of Normal Supply Consumed, h/ne

*In the event that no conservation policy is to be followed, P and Q are each set equal to 1.0.

(c) The foregoing identifies the manner in which the firepower is constrained by supply shortages for men, types of tank, types of light armor, types of ground mounted antitank weapon, types of mortar, and types of artillery.* When supply shortages occur in the Blue cavalry units, the helicopters in those units are constrained as follows. Only as many helicopters will fly as can do so fully laden with POL and ammunition. For example, if there is only enough POL for one-third of the unit, then no more than one-third of the helicopters will fly during that period, and the helicopter IFP is reduced accordingly.

(2) Artillery firepower may also be constrained by a shortage of cannoneers to serve the available cannon. If the number of cannoneers falls below the minimum number required to serve the cannon, the artillery firepower values and ammunition consumption are reduced to reflect the reduction in expenditure. As above, the P and Q values (input) must lie between zero and one.

(3) An additional constraint is placed on the helicopters, concerned with the enemy capability against helicopters and acceptable loss rates by the Blue commander. The general rule for helicopter constraint is given for each type of helicopter by:

$$F = \min \left[F_{POL}, F_{ammo}, \frac{R_A}{S_E R_K} \right]$$

where:

F = fraction of helicopters that fly during the period

F_{POL} = h/ne for POL, i.e., fraction of normal supply of POL consumed

F_{ammo} = h/ne for ammunition, i.e., fraction of normal supply of ammunition expended

R_A = acceptable loss rate of this type helicopter by Blue commander.

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*Ammunition is the only supply category represented for artillery battalions.

R_K = expected rate of helicopter kills made by a full strength enemy division (function of helicopter type and type of Red division)

S_E = state of the enemy division, i.e., current firepower capability divided by his full strength firepower capability.

f. Artillery Neutralization

(1) As indicated earlier, DS artillery may suffer partial neutralization by enemy GS artillery. It is accomplished by enemy GS artillery battalion equivalents that are not allocated to reinforcing DS fire support. The amount of GS artillery antipersonnel firepower specified for the counterbattery role is applied. The fraction F_N of DS artillery that is neutralized (and therefore not effective for this engagement) is determined as follows:

$$F_N = 1 - e^{-K(CBAP_e/DSBN_f)}$$

where:

$DSBN_f$ = the number of friendly DS battalions under fire

K = DS neutralization vulnerability coefficient

$CBAP_e$ = the amount of enemy counterbattery firepower in the subsector designated for the antipersonnel category.

(2) The artillery firepower is then determined as follows. The number of nonneutralized DS artillery battalions in support of the engagement is compared with the number of maneuver battalions (or regiments) being supported to determine whether all of the artillery battalions can be used effectively. An input table labeled "Artillery Coordination Degradation Factor" is used for this. If the number of artillery battalions is too high or too low with respect to the number of supported battalions, then it may be reduced by use of the input table to an "effective number" of battalions which is then multiplied by the three per battalion IFP scores.

g. Effective Firepower Array

(1) After the firepower has been constrained by supply shortages for each type of major weapon in the status file, the resulting modified firepower values are grouped by source and capability into the following 3 x 6 array.

	Hard	Medium	Soft	Hel	Arty	CAS
AT						
ALA						
AP						

Figure 5-2. Firepower Array

All of the antitank firepower coming from all the tanks (hard sources) of all types is summed and placed in the upper left compartment. The sum of AT firepower from light armor is placed in the upper compartment of the medium column, etc. The soft column receives all firepower from the ground-mounted antitank weapons, mortars and personnel weapons.

(2) After the firepower array has been constructed for each of the six status files involved in the engagement, the four on the Blue side (brigade, portions of two cavalry units, and artillery) are summed to form one Blue array. The Red array is summed from the division and artillery status files. Then for each side, a CAS column is added to form the complete 3 x 6 array which, after modification for flank defense, is ready for use in calculating casualties, losses, and FEBA movement.

5-4. ENGAGEMENT RESULTS. After the Blue and Red firepower arrays have been constructed and modified, the values therein are used to determine combat casualties, losses, and FEBA displacement.* Combat casualties are based on the AP firepower generated on one side applied against the number of personnel outside of the major combat vehicles on the other, along with the creation of casualties from among the crews of damaged vehicles. The numbers of ground

*Noncombat casualties and losses are also produced during engagement assessment.

vehicles (tanks and APCs) damaged in combat are based on the AT and ALA firepower, respectively, generated on one side applied against the numbers of such vehicles on the other side. The numbers of ground-mounted antitank weapons and mortars lost are based on the number of dismounted personnel casualties. The displacement of the FEBA is a function of a calculated force ratio taking into account the types of firepower and types of target involved. The equations used to determine vehicle losses, casualties and FEBA displacement follow.

a. Heavy and Light Armor Losses. The tanks and APCs that are lost in a CEM engagement consist of those that are damaged and/or destroyed from battle and those that break down from nonbattle causes. Of those that are damaged but not destroyed, some are abandoned and the rest are sent to repair. Some of the nonbattle losses are also abandoned; the rest are sent for repair.

(1) Tank Losses. The number of Blue tanks of type n that are damaged in an engagement, H_{Tn}, is given by:

$$H_{Tn} = T_n \left[1-e^{-K_n(ATFP)/\sum T_m}\right]$$

where:

T_n = the number of tanks of type n in the engagement subsector (includes tanks from brigade and division cavalry and corps cavalry that are fighting in the subsector during current division cycle).

ATFP = volume of enemy antitank firepower from all sources (hard, medium, soft, helicopter, artillery, CAS) from the enemy 3 x 6 firepower array as modified above.

K_n = damage coefficient of enemy antitank firepower against a tank of type n.

$\sum T_m$ = total number of all Blue tanks of all types from brigade and supporting cavalry units in the subsector during the current division cycle.

The number of Blue tanks of type n that are destroyed is given by:

$$D_{Tn} = d_{Tn} H_{Tn}$$

where: d_{Tn} = the fraction of damaged tanks of type n (those that are damaged from previous computation) that suffer total destruction (k kills).

Some of the tanks that are damaged in battle but not totally destroyed are abandoned under adverse FEBA movement. Their number (for tanks of type n in the subsector) is given by:

$$A_{Tn} = [H_{Tn} - D_{Tn}][1 - e^{-a_T M_F}]$$

where: H_{Tn} and D_{Tn} are as previously defined and

a_T = the abandonment coefficient for all tank types

M_F = FEBA movement (in tenths of a kilometer) of subsector front for current division cycle.

All of those tanks that do not suffer battle damage are candidates for nonbattle breakdown. The number of tanks of type n in the subsector that break down is given by:

$$B_{Tn} = b_{Tn} [T_n - H_{Tn}]$$

where: b_{Tn} = the breakdown rate per division cycle of tanks of type n

$T_n - H_{Tn}$ = the number of tanks of type n in the subsector that have not suffered battle damage in the current division cycle. This calculation is also applied to tanks in the reserve brigades.

Those battle damaged tanks that are neither totally destroyed nor abandoned are sent to the repair pool to be repaired and made available for future combat. Other tanks that are sent to the repair pool consist of a portion of those that break down. Thus the number of tanks of type n that go to the repair pool from the subsector during the current division cycle is given by:

$$R_{Tn} = (1-d_{Tn})H_{Tn} + r_{Tn}B_{Tn}$$

where: d_{Tn}, H_{Tn} and B_{Tn} are as previously defined and

r_{Tn} = fraction of breakdowns that are deemed repairable.

(2) Light Armor Losses. The foregoing set of equations defines the losses suffered by Blue tanks in the engagement from Red antitank firepower and from breakdowns and identifies the number being sent for repair. The same equations are used for Blue light armor losses where one simply inserts the name light armor wherever tank is used and Red antilight armor firepower where he sees Red antitank firepower. The same equations are also used for calculating Red heavy and light armor losses and the numbers sent for repair. The nonbattle losses defined above also apply to the reserve brigades (Blue) and divisions (Red).

b. Losses to Ground-mounted Antitank Weapons and Mortars. The ground-mounted antitank weapons and mortar losses are calculated only indirectly as a function of the fire directed against them. Their losses are given by:

$$H_{An} = R_{An} \left(\frac{C_p}{M}\right) A_n$$

where: H_{An} = the number of weapons of type n that are knocked out

R_{An} = an input number representing the fraction of weapons lost per percent of personnel casualties

C_p = the number of casualties taken by the unit during the engagement (see below)

M = the number of men in the engagement who are in the "personnel pool" (see below)

A_n = the number of weapons of type n in the engagement.

None of these damaged weapons are considered for salvage nor repair.

c. Casualties

(1) The casualties in an engagement come from the crews of damaged vehicles and from the men outside the vehicles as represented by the "personnel pool" in the status file. Those casualties to crew resulting from vehicle damage are defined by input data which give the number of killed and wounded as a function of the type of vehicle damaged. Those casualties coming from the personnel pool are dependent on the density of personnel in the subsector and upon the total volume of antipersonnel firepower delivered by the enemy into the subsector. The casualties to the personnel pool are given by:

$$C_p = M[1-e^{-K(APFP)/N_m}]$$

where: M = number of men in the subsector that are not in vehicles. When Blue casualties are being calculated, this includes the men from the brigade and cavalry units that are participating

APFP = volume of antipersonnel firepower from all sources (hard, medium, soft, helicopter, artillery, CAS) from the enemy 3 x 6 firepower array as modified above. When Red casualties are being calculated, this includes firepower from the brigade and cavalry units

K = personnel vulnerability coefficient

N_m = the number of minisectors in the subsector.

The casualties, C_p, are then categorized as killed, wounded, and missing by the use of input fractions that are dependent on the type of engagement.

(2) Along with the combat casualties, disease and nonbattle injuries (DNBI) are calculated for the engagement by use of an input fraction applied against the number of personnel in the engagement. DNBI are also assessed against the reserve brigades (Blue) and divisions (Red). Another input fraction is applied to determine the DNBI who die.

(3) After the casualties have been assessed, their destination is determined. The killed and missing are simply dropped. A portion of the wounded, defined by an input fraction, go to

hospitals in the theater. A portion of these, defined by an input fraction, are evacuated from the theater. The remainder go to the battalion aid station and return for duty in the following division period. Those that go to the hospitals but are not evacuated from the theater are later placed in the theater replacement pool for return to duty. The crews from damaged vehicles who are neither killed nor wounded are placed in the personnel pool of the appropriate status file to fight as infantry while awaiting the arrival of replacement vehicles.

d. Helicopter Losses. The losses to the Blue helicopters that are participating in the engagement from the division and corps cavalry is a function of the Red division capability against helicopters, the state of the Red division and the number of Blue helicopters flying. The number of helicopters of type n that are damaged in the engagement is given by:

$$H_{Hn} = S_E R_{Kn} N_{Hn}$$

where:

S_E = the state of the Red division at the beginning of the division cycle (where the state is calculated as the percentage of full strength firepower that is now available to the unit)

R_{Kn} = the rate of expected kills made by the Red division on the helicopters of type n flying against it (function of Red division type, helicopter type, and type of engagement)

N_{Hn} = the number of helicopters of type n participating in the engagement. This is the number after supply constraints and acceptable loss constraints have been applied.

The number of helicopters that are retrievable from among the damaged helicopters of type n is given by:

$$R_{Hn} = H_{Hn} e^{-H_{Rn}(R_f)}$$

where:

H_{Hn} = is as defined previously

R_f = rate of adverse FEBA movement in tenths of a kilometer

H_{Rn} = helicopter retrieved rate coefficient for type n helicopters.

Those battle damaged helicopters that are retrieved are sent to the repair pool. Other helicopters sent for repair consist of a portion of those that break down. The number of breakdowns is found by applying an input fraction each division period, and the number of breakdowns that are sent for repair is found by applying another input fraction.

e. Static Engagement Assessment. Personnel casualties and equipment losses in static engagement situations result only from the DS artillery and CAS fire allocated to this subsector by each side.

(1) Casualty Assessment. Casualties resulting from the DS artillery and CAS fire are assessed using the same methodology described under Casualties above. Thus the casualties C_S in static engagement are given by:

$$C_S = M \bullet [1 - e^{-K_S(APFP_D)/N_m}]$$

where:

M = number of men in the subsector that are not in vehicles

K_S = personnel vulnerability coefficient for static engagement

$APFP_D$ = the total antipersonnel firepower from enemy DS artillery and CAS in this static engagement

N_m = the number of minisectors in the subsector.

(2) Heavy and Light Armor Losses. Heavy and light armor losses resulting from the DS artillery and CAS fire during a static engagement are assessed using the same methodology as described earlier in para 5-4a, Heavy and Light Armor Losses. The

total DS AT or ALA firepower in the subsector from artillery and CAS is substituted for the terms ATFP or ALAFP, as the case may be, in the respective algorithm. All other terms are as defined earlier. Distinction is made between those vehicles that are destroyed or damaged only, and the remaining vehicles are subject to breakdown and repair. Since there is no FEBA movement in a static engagement, no vehicles are abandoned.

f. Reserve Unit Assessment. Personnel casualties and equipment losses in reserve units result only from enemy artillery and CAS fire allocated to the GS role. Since the locations of reserve units, as well as GS artillery battalions, are not specified in the CEM, it is presumed that the enemy GS fire is distributed equally among all units in reserve. Thus the GS firepower received by each unit (Blue brigade or Red division) is determined by summing all enemy GS firepower from artillery and CAS across the front and dividing by the total friendly units in reserve.

(1) Personnel Casualties. Casualties in a reserve brigade or division resulting from enemy GS AP firepower, C_R, are given by:

$$C_R = M \bullet [1 - e^{-(K_R)(P)(APFP_G)}]$$

where:

M = number of personnel in the unit that are not in vehicles

K_R = personnel vulnerability coefficient for reserve

$APFP_G$ = the total amount of enemy AP firepower from GS fire

P = factor representing the proportion of total enemy GS firepower that would be expected to be directed to this unit in reserve (this may be thought of as a ratio of the area occupied by the reserve unit to the total area over which GS fire would be distributed).

Casualties in reserve units are categorized as killed or wounded, and are hospitalized or evacuated as is done with casualties in on-line units.

(2) Heavy and Light Armor Losses. Heavy and light armor losses inflicted by the GS artillery battalions and CAS on reserve units are assessed using the same methodology as described in para 5-4a, Heavy and Light Armor Losses, earlier. The applicable firepower is the total enemy GS AT or ALA firepower multiplied by the above described proportionality factor. Other terms are as defined earlier. Distinction is made between those vehicles that are destroyed or damaged only, and the remaining vehicles are subject to breakdown and repair. No vehicles are abandoned.

g. DS Artillery Unit Casualties

(1) Casualties in the DS artillery battalions are caused by enemy counterbattery firepower in all types of subsector engagements. The AP component of this firepower is equally distributed to all DS battalions operating in the subsector. Casualties, C_A, are determined by

$$C_A = M \bullet [1 - e^{-K_{CB}(APFP_{CB})/N_{BN}}]$$

where:

M = number of cannoneers in the targeted DS artillery battalion

K_{CB} = personnel vulnerability factor from enemy counterbattery fire

$APFP_{CB}$ = the amount of enemy counterbattery AP firepower in the subsector

N_{BN} = number of friendly DS artillery battalions in the subsector.

The casualties, C_A, are then categorized as killed or wounded by the use of an input fraction for artillery units.

(2) After casualties are subtracted from the artillery battalion personnel, the fraction of DNBI casualties are determined by use of an input factor for artillery units. All DNBI cases are considered to be hospitalized, and are thus removed from the personnel on hand in the artillery battalion status file.

(3) Cannon may be destroyed by both antitank and antilight armor counterbattery firepower. The number of cannon that are destroyed by counterbattery fire, D_{CN}, is given by:

$$D_{Cn} = C_n \bullet \left[1 - e^{-[K_{ATn}(ATFP_{CB}) + K_{ALAn}(ALAFP_{CB})]/\Sigma C_m}\right]$$

where:

C_n = the number of friendly type n cannon with a DS mission in subsector engagement

K_{ATn} = vulnerability factor of cannon type n to enemy AT firepower

$ATFP_{CB}$ = volume of enemy counterbattery AT firepower in the subsector

K_{ALAn} = vulnerability factor of cannon type n to enemy ALA firepower

$ALAFP_{CB}$ = volume of enemy counterbattery ALA firepower in the subsector

ΣC_m = total number of all friendly DS artillery cannon in the subsector engagement.

The CEM does not include any maintenance cycle for damaged artillery weapons; thus it must be assumed that cannon hit by enemy fire are either destroyed or repaired within the (12-hour) division cycle. No artillery battalions are assumed to be overrun.

h. FEBA Movement

(1) The final part of the engagement assessment is the resultant displacement of the FEBA. It is determined by comparing threshold values (inputs to the model) against a force ratio of attacker to defender. Four threshold values are used for each attack/defense posture resulting in five possible FEBA displacement values. The force ratio that is compared against these thresholds is constructed from the two 3 x 6 firepower arrays in such a way as to take both the types of weapon and target into account. Below are shown two hypothetical firepower arrays, one for Blue and one for Red, to represent the modified firepower values of each side just prior to the formation of the firepower ratio. The Blue array includes firepower from the brigade, division cavalry unit, corps cavalry unit, artillery battalions, and CAS. The Red array

includes firepower from the maneuver element of the division plus artillery battalions and CAS. For those units mentioned above that have only a portion of their firepower committed to this engagement, a prorated portion has been included. The firepower values in the two arrays represent the firepowers remaining after all modifications mentioned previously (by terrain factors, supply shortages, etc.) have been performed. They will now be used to explain and illustrate the calculation of the force ratio.

Table 5-2. Hypothetical Blue Force Firepower Scores

Target	Shooter						Total
	Hard	Medium	Soft	Helicopter	Artillery	Close air support	
Tank	20	30	10	7	2	8	77
Light armor	10	15	15	10	10	10	70
Personnel	5	10	20	5	50	5	95
Total	35	55	45	[a]	[a]	[a]	242

[a]Not used.

Table 5-3. Hypothetical Red Force Firepower Scores

Target	Shooter						Total
	Hard	Medium	Soft	Heli-copter	Artil-lery	Close air support	
Tank	10	15	10	1	0	1	37
Light armor	20	15	12	2	0	3	52
Personnel	10	12	20	5	30	15	92
Total	40	42	42	[a]	[a]	[a]	181

[a]Not used.

(a) An appropriately weighted total effective firepower is employed for Blue and Red separately so that their ratio may be computed. The total effective firepower presented in the Blue array is 242. But this assumes that there are appropriate targets for all the weapons which contribute to the effective firepower. The AT, ALA, and AP weapon systems are weighted so that each contributes to the final value only so much firepower as is justified by the presence of enemy targets. Note that the total Blue AT firepower is 77. This is weighted by Red targets in the following manner. The total of the Red scores on the battlefield (not counting artillery and helicopters) is the sum of the first three columns, or 124. Of this, 40/124 is credited to the Red tanks ("hard" shooter). This factor is taken as the weighting factor for the Blue AT score of 77. Thus Blue's AT contribution to the total Blue score is 40/124 x 77 or 24.8.

(b) In like manner, the weighted Blue ALA score is 23.7 and the weighted Blue AP score is 32.2. The total Blue firepower is 80.7.

Similarly the weighted total firepower of Red is:

$$37 \times \frac{35}{135} + 52 \times \frac{55}{135} + 92 \times \frac{45}{135} = 61.4.$$

If Blue is attacking, the force ratio is 80.7/61.4 = 1.31. The equation which concisely expresses the above relationship is:

$$\text{Weighted Force Ratio} = \frac{\sum_{n=1}^{3} R_{nb}\, C_{nr} \sum_{n=1}^{3} C_{nb}}{\sum_{n=1}^{3} R_{nr}\, C_{nb} \sum_{n=1}^{3} C_{nr}}$$

where:

R_{nr} = the total of the n^{th} row of the Red array.

R_{nb} = the total of the n^{th} row of the Blue array.

C_{nr} = the total of the n^{th} column of the Red array.

C_{nb} = the total of the n^{th} column of the Blue array.

(2) The resultant displacement of the FEBA is a tabular function of the engagement outcome, the type of terrain, and, if the engagement is Blue delaying, whether or not a barrier is being breached. If Blue is delaying from a barrier, the value of the FEBA movement may be modified downward to reflect the barrier clearing time. These tabular values must be provided as input to the model.

i. Effects of Exposed Flanks. A brigade is said to have an exposed left (right) flank if the FEBA of the brigade's left (right)-most minisector is ahead of the adjoining minisector FEBA of its left (right) neighbor. A subsector is said to have an exposed left (right) flank if the subsector FEBA is ahead of that of its left (right) neighboring subsector.

(1) Units that are overextended (in the sense of flank-to-front ratio) are usually penalized in real life through loss of

either terrain or fighting strength. In extreme cases they may be surrounded and destroyed. Such envelopment is not possible in the model because movement of forces across sector boundaries is not permitted. Therefore only terrain penalties are simulated, and the next three paragraphs describe FEBA adjustments made as a result of over-extension.

(2) At the end of a division period on terrain types A, B, or C (i.e., in the absence of major obstacles) a defending (or delaying) brigade (or Red division) draws each subsector back until it has at most one exposed flank. If a subsector has only one flank exposed at the end of the period, no adjustment is made for that subsector.

(3) An attacking brigade (or Red division) that has both flanks exposed as a result of the FEBA changes at the end of a division period (including those changes described above for the defensive line) may, during the ensuing division situation estimate, be given an attack mission if it can expect at least a draw without additional support.* If it cannot expect a draw or win, it may only be given a defensive mission. In the event that it is given an attack mission for the ensuing period on the basis of the situation estimate, it suffers the usual casualties and losses for that period but does not advance since discretion requires that it not increase its flank exposure.

(4) Any subsector of an attacking brigade (or Red division) that is extended beyond adjacent subsectors to the extent that each flank of the subsector is longer than the subsector width will not advance even though the engagement result would allow it to do so. The flank length is measured in tenths of a kilometer and the subsector width in minisectors.

j. Limitations on Flank Length. After the FEBA has been moved for the subsector as a result of battle outcome and constrained by the rules on exposed flanks as identified above, one final rule is applied as a final limit on flank length as follows. A maximum allowable subsector flank length, L, is identified (an input number) and is used as a constraint on all subsector FEBA displacements. The new FEBA location is compared with the new FEBA location of the adjacent subsector that has just been assessed (the one on the north in a battle of east-west movement). If the distance between the two subsector FEBAs is not greater than the

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*See para 6-2, Division Estimate of the Situation.

limiting value, L, then the new FEBA location of the currently assessed subsector remains in its new position. Otherwise, the new FEBA location is moved backward or forward (as required) until the distance between the two subsector FEBAs is separated by the distance, L, along their common boundary. Thus the movement of each subsector is constrained by the movement of the subsector on its north side, sometimes being drawn forward with it, at times being held back by it.

k. Major Obstacles. One more rule applies in the vicinity of terrain type D that has nothing to do with flank security but is noted here for completeness: when an attacking subsector force on non-D terrain gets a FEBA change (as a result of winning or drawing an engagement) that would pass over a strip of D terrain, then the subsector force must stop at the edge of the obstacle and must fight a subsequent engagement to cross over.

CHAPTER 6

DIVISION CYCLE

6-1. GENERAL. The division cycle consists of estimates of the situation made by the division commanders (automated), the engagements, and resupply.

6-2. DIVISION ESTIMATE OF THE SITUATION (BLUE). At the beginning of each period,* several tactical decisions are made at division level, based on the division estimate of the situation. These decisions include allocation of fire support to brigades, assignment of brigade missions, and commitment or reconstitution of a division reserve. The estimate of the situation consists of estimating the outcomes of brigade engagements, assuming various hypothetical decisions. The availability of CAS is not considered in the estimate.**

a. Case I: Reserve Brigade Uncommitted

(1) For each brigade (separately) the state is compared with mission thresholds to determine the most aggressive mission the brigade may undertake at this time.*** A tentative allocation of 1/3 of the cavalry units available to the division (i.e., 1/3 of the division cavalry unit and 1/3 of that part of the corps cavalry unit that has been assigned to support this division) is assigned in support of each brigade. An estimate (described below) is made of the enemy mission, position type (if appropriate), and numbers and states of units of each type facing each friendly brigade. On the basis of these factors and knowledge of the terrain,

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*Just prior to the assessment of engagements, the FEBA of each subsector is straightened to the average location.

**The reason for this is that, in practice, a commander, because of weather and other operational uncertainties, usually cannot be sure enough of CAS to include it in making his plans.

***In order to prohibit a brigade from remaining in reserve for an extended period of time while the state of the two forward brigades falls to too low a level, the reserve brigade is exchanged with the weakest on-line brigade at this time if the state of the reserve brigade exceeds that of the weakest brigade by at least D state points, where D is an input to the model.

the engagement outcome is estimated for each sector by a process closely approximating the process that determines the FEBA movement in the actual engagement results. A 3 x 5 modified firepower array is constructed for the brigade in question and for the estimated enemy force. From the two arrays a firepower ratio is calculated as described previously in para 5-4, Engagement Results. The firepower ratio is compared to two thresholds to place the estimated outcome into one of three regions: win, draw, or loss. (No calculation of casualties or losses is made for the estimated outcome.)

(a) The two arrays that give rise to the ratio above are approximations to the 3 x 6 arrays that are used in calculating the actual engagement results and are formed as follows. For the estimated Red force (which may include parts of more than one division) facing the brigade, the full strength meeting engagement firepower values of the maneuver regiments (or portions thereof) are collected by source (hard, medium, or soft firer) and capability (AT, ALA, AP) to form the elements in the first three columns of the 3 x 6 array. Each element is then multiplied by an estimated state/100 of the parent divisions. The helicopter column remains zero. The number of estimated artillery battalions providing DS and GS reinforcing fire is compared with the estimated number of maneuver regiments being supported to determine the number of artillery battalions that can be used effectively. (See para 5-3f, Artillery Neutralization, under Effective Firepower Development.) The full strength meeting engagement firepower values of the estimated effective enemy divisional DS battalions, along with that from any divisional GS and nondivisional composite GS battalions firing in direct support, are collected to form the artillery column of the array. The elements in the resulting array are multiplied by posture factors appropriate to the estimated engagement type and by terrain factors* to form the final estimated enemy array.

(b) On the Blue side, the 3 x 6 array is approximated in a similar manner with the following exceptions. The information on numbers of Blue battalions is known and the process is complicated by the addition of Blue cavalry units. The array is initialized by placing the full strength meeting engagement firepower values of the brigade's maneuver battalions into the elements of the

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*For the purpose of estimation, no part of the combat forces is considered to be placed along the flanks (as they are in the engagement calculation).

first three columns of the array. These elements are then multiplied by the brigade state divided by 100.*

(c) For each cavalry unit a current per helicopter four-column array is formed by dividing the number of helicopters remaining in the unit into that array for the unit in a meeting engagement. The number of helicopters that are considered for supporting the brigade in question from a given cavalry unit is multiplied by the appropriate per-helicopter array. The two supporting cavalry unit (one from corps, one from division) arrays thus formed are added to the Blue brigade array. At this time the elements in the first three columns are multiplied by posture factors appropriate to the estimated engagement type and the helicopter column is modified as follows. If the expected helicopter losses are above the acceptable limit, the elements in the helicopter column are multiplied by the acceptable loss rate and divided by the product of the estimated Red division state/100 and the weighted kill potential against helicopters.

(d) The elements in the Blue artillery column are calculated in essentially the same manner as they are for the estimated Red with an important distinction (aside from the fact that the number of battalions is known instead of estimated). The distinction is that the Blue division commander in arriving at his mission decision for the brigade, mentally employs various levels of supporting artillery fires. The first level so employed is that of the DS battalion firing at the normal expenditure rate in support of the brigade. Thus the elements in the artillery column include the modified full strength meeting engagement firepower of the brigade's DS artillery battalions. The modifications include the identification of a number of "effective" battalions by comparing the number of supporting artillery battalions with the number of supported maneuver battalions. Also included is a multiplication by a posture factor appropriate to the estimated engagement type. The elements of the artillery column are then included in the Blue firepower array.

(e) Finally, the resulting array is modified by terrain factors and, if a Blue prepared defense is estimated, by prepared defense terrain factors as in the actual engagement calculation.

(2) The outcome estimation is repeated under the following conditions:

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*Recall that if supply shortages exist, the appropriate constraining effects are reflected in the state value during estimation.

(a) Increased expenditure for DS artillery.* The increased expenditure is a function of the types of cannon that are employed in the battalions.

(b) A specified fraction of the divisional GS and nondivisional GS composite battalions available to the division is assigned to the direct support role, plus condition (a).

(c) Division reserve committed, plus condition (b). The reserve brigade is committed to a sector by assigning it half the minisectors in the sector, the remaining half being covered by the original brigade.

The commitment is made so that the brigade of lower state is assigned to the interior sector of the division.** Under condition (c), the outcome is estimated for all three brigades.

b. Case II: Reserve Brigade Committed. In case the division reserve is already committed from an earlier period, the first step is to consider reconstituting a division reserve. This is done as follows. For each brigade and the forces opposing it, the ratio of IFP is calculated; this ratio is denoted by BRIFP. A virtual (imaginary) withdrawal is made of the brigade with the lowest state, and the resulting gap is filled by spreading out the brigade with the higher BRIFP. The estimate of the situation now proceeds by following the steps outlined above for the case of the uncommitted reserve force.

c. Estimate of Enemy Mission. In estimating the outcome of brigade engagements, the division must estimate both the enemy mission and force size. This is complicated by the fact that a brigade may face elements of more than one unit, having different missions.

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*The history arrays for future estimations reflect this increased expenditure (when employed) as an additional number of artillery battalions.

**This rule, while not critical, is made with an eye toward reserve reconstitution. As explained later, the brigade of lowest state is selected when reconstitution is decided on, and the resulting gap can be filled in a more realistic way if this brigade is in the center rather than on the division flank. This is because either of two brigades is available to be spread out in the former case, but only one in the latter.

(1) When the friendly division is considering an attack mission, the enemy mission is estimated to be the same as it was in the previous period, provided that it was the same for all enemy elements faced. If it was not the same for all elements, the enemy mission is estimated to be defense.

(2) When the friendly division is considering a defense or delay mission, the enemy mission is also estimated to be the same as it was in the previous period, provided that it was the same for all enemy elements faced. If it was not the same for all elements, the enemy mission is estimated to be attack.

(3) In the special case of the first period of the war, the estimated mission of an enemy unit is taken to be the actual mission of the enemy echelon above division (Blue corps or Red army).

(4) Whenever the enemy mission is estimated to be defense, an estimate must also be made of the type of position. This is done by applying the inequality shown previously in para 5-2c, Defensive Positions, using the correct value for D* and the past FEBA movements for the minisectors in the friendly brigade sector.**

d. Estimate of Enemy Force. The number of enemy battalions (equivalent) of each type is estimated separately. The estimated number is taken to be a weighted average of:

--the (actual) number in the last period, N_{i-1}

--the (actual) number in the next-to-last period, N_{i-2}

that is,

$$N_i = a\, N_{i-1} + b\, N_{i-2}$$

These numbers refer only to battalions capable of undertaking the estimated enemy mission and therefore not necessarily to all the enemy battalions present.

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*When Blue is the defender, the value used by Red for D is a specified input threshold, not the threshold(s) designated for the individual division(s) involved.

**As a consequence of this rule, the estimate of the position type will be correct whenever the brigade faces only one enemy brigade (equivalent). When it faces more than one, the estimate will be approximately, but not necessarily completely, correct.

(1) In the special case of the first two periods of the war, N_i and N_{i-1} are both taken to be the actual numbers at the beginning of the war.

(2) The coefficients are related to the average age of the information on which the estimate is based. For example, if this information is one period old on the average, then a = 1, b = 0. If it is two periods old, then b = 1, a = 0.

(3) It is possible to give the Blue forces an advantage reflecting an introduction of advanced information systems equipment by turning on a Tactical Operations System (TOS) "switch" in the model which changes the meaning of a and b above. The effect of turning the TOS switch on is to change the subscripts in the above equation for a Blue estimate of the situation (but not for Red), so that i is replaced by i+1, and i-1 is replaced by i. This provides the Blue forces with more up-to-date information than is provided to the Red forces.

(4) The estimated states by which the full strength IFP arrays of the battalions are multiplied for the outcome calculation are determined in the same manner as above, with a separate set of specified coefficients. The estimated state, S_i, is calculated as:

$$S_i = a\, S_{i-1} + b\, S_{i-2}$$

where S_{i-1} and S_{i-2} are the average values of the states of those forces which occupied these particular minisectors during periods i-1 and i-2. If the TOW switch is on, this estimate is affected the same as described above.

6-3. DIVISION DECISIONS (BLUE)

a. The division estimate of the situation having been completed, the most favorable (estimated) outcome in each sector is identified, and the least support necessary to achieve this outcome is determined. If the best outcome in a sector is a loss, then the brigade considers a mission one step below that previously considered (i.e., defend instead of attack, or delay instead of defend). Otherwise the brigade is assigned the previously considered mission and allocated the minimum support needed to achieve the best outcome, except that if the best estimated outcome is a draw, the maximum support is allocated.

b. Certain special cases arise from the fact that the division reserve cannot be committed to both sectors simultaneously.* If the situation is such in both sectors that committing the reserve would convert a loss to a draw,** then (1) the reserve is not committed, and (2) brigades consider missions one step below those previously considered. If committing the reserve in sector 1 results in a win*** in sector 1, and committing it in sector 2 results in a draw in sector 2, the reserve is committed to sector 1. If the situation is such in both sectors that committing the reserve would result in a win:

(1) And the outcome without the reserve is different for the two sectors, then the reserve is committed to the sector expecting a loss;

(2) And the outcome without the reserve is the same for the two sectors, then the reserve is committed to the sector yielding the greater number of wins in the two new sectors; if the number of wins is the same, the reserve is committed to the sector with the highest BRIFP.

c. Another special case concerns reserve reconstitution, which begins with a virtual withdrawal of one of the brigades. If the subsequent steps in the estimate of the situation and resulting decisions do not lead to reserve commitment, then the virtual withdrawal becomes actual, and the withdrawn brigade becomes the division reserve. If the steps do lead to reserve commitment, then the brigade is not withdrawn.

d. Finally, in case the reserve is not committed, the extra DS artillery battalion (normally available to the reserve brigade) is assigned to one of the brigades on line in accordance with the following priority scheme. If the brigade missions are different,

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*The rule assigning the reserve brigade to one half the mini-sectors in a specified sector was made in the interest of simplicity. Rules governing reserve assignment to a wider choice of location and frontage would be unwieldy, and it is doubtful whether the state of our knowledge would permit writing rules that would lead to substantially greater realism.

**Defined as a draw in at least one of the two new sectors.

***Defined as a win in at least one of the two new sectors.

the artillery battalion is assigned to the brigade with a delay mission, if there is one, and otherwise to the brigade on attack. If both brigades are defending or both delaying, the battalion is assigned to the one with the lower BRIFP.

e. If the entire decision process as described above leads to incompatible missions, i.e., one of the division's brigades having a delay mission alongside another with an attack mission, it has probably resulted from inequitable frontages being assigned to the brigades. Whenever this occurs, the division decision is cancelled, and the following is done. First, the division reserve is reconstituted by withdrawing the weakest brigade. Second, a minimum brigade frontage (1/3 of the division front) is established to preclude the narrow frontages that resulted in the original situation. Finally, the normal division decision cycle is repeated to determine missions and reserve disposition. In the repeat cycle, any combination of attack/delay missions resulting is disallowed by downgrading the attack mission to defend.

f. When estimates are complete for all brigades in the division, a final adjustment is made in cavalry unit allocation to each on-line brigade, depending on the missions undertaken and the force ratios first calculated in the estimates. If three brigades are committed, no further adjustment is made. If two brigades are committed and one is retained in reserve, that portion of the cavalry units that was tentatively supporting the reserve brigade is distributed dependent upon estimated brigade mission outcome, as follows:

(1) If both brigade estimated outcomes are "win," no further adjustment is made, and a portion of the cavalry force is held in reserve.

(2) If both brigade estimated outcomes are the same and are either "draw" or "lose," then the remaining cavalry support is divided equally between the two active brigades.

(3) If the brigade estimated outcomes are different for the two brigades, then the remaining cavalry support is assigned to the brigade with the lower estimated outcome.

g. After these decisions concerning the ground forces have been made, the CAS sorties available for support of the division are allocated. First, the sorties are divided between GS and DS in the same ratio as the artillery battalions available to the division. Second, those sorties assigned to DS (and therefore counted in determining engagement outcomes) are allocated to engaged brigades in proportion to the DS role artillery allocated to each brigade.

h. There is no delay in implementing any of the decisions made at division level.

6-4. RED DIVISION ESTIMATE OF THE SITUATION AND DECISIONS. The Red division makes only two tactical decisions: its mission and the degree of enhancement of DS firepower. The basis for these decisions is an estimate of the situation similar to that for a Blue division. The Red force is not resolved below division level, and thus questions concerning missions for each regiment and commitment or reconstitution of division reserve do not arise.

6-5. ENGAGEMENTS. Following the estimates of the situation by the division commanders, the engagements occur for each subsector along the front as described earlier. The depleted forces then receive available resupply and replacements.

6-6. RESUPPLY AND REPLACEMENTS

a. At the division cycle level, the unit status file allows detailed interplay of resource consumption and replenishment. Men, major items, and supplies are spent at varying rates dependent on the intensity of combat and on the particular capability of the enemy. More resources are spent overall during an attack than during a static situation, and more tanks are destroyed by an enemy with heavy AT potential than by one that has mainly an AP capability. These variations in losses are recorded in the unit status file.

b. A portion of the wounded and sick personnel are removed to hospitals (the remainder go to the battalion aid station and return to combat in the next cycle). Of those that go to hospitals, some go to fixed bed hospitals in the theater (see para 2-2, Representation of Logistic Functions) for eventual return to combat; others are evacuated from the theater and will not return to the current battle. The proportion that is evacuated depends on the evacuation policy and is included as input to the model. The damaged vehicles that are considered repairable are taken to the maintenance facilities for repair and eventual return to combat.

c. As the items in the status file are reduced by combat, sickness, and breakdown they are replenished if replacements and resupply are available. However, the priorities of replenishment may differ for the Blue and Red sides because of a basic difference in policy options.

d. Crew-served weapons (generally major items or combat vehicles) exchange personnel with the status file personnel pool such that uninjured crews of damaged and inoperative weapons are

returned to the personnel pool in each division cycle and personnel are taken from the pool to crew replacement weapons received during the division cycle replenishment process.*

e. Blue replenishment:

(1) On the Blue side, replenishment of men, major weapons, and supply is performed on the basis of need for all user units, i.e., brigades, artillery units, division cavalry units, and corps cavalry units. If, for example, one user unit needs twice as many men as another user unit, then the first unit receives twice as many men as the second unit from among the men available as replacements. If, on the other hand, the first unit needs only half as many M60 tanks as the second, then it receives half as many from among the M60s available as replacements. (In these examples, the number of available replacements is assumed to be less than the total needed.) The same rule applies to the resupply of ammunition, POL, and other supply.

(2) The amount of replenishments available is dependent on theater policies that are input to the model. At the beginning of each theater cycle the amounts of each item that are available are apportioned equally to the number of division periods within the theater period and these amounts become available to the user units during each ensuing division period. If the amount available exceeds the demand, it is not lost, but is retained until needed. However, the user units are not allowed to accumulate (for use) more than their full strength status calls for.

(3) As resupply and replacement major weapons reach the user unit, they are immediately available for combat. However, this is not the case for replacement personnel, who must be assimilated into the unit over a period of time. This is accomplished as follows. As the replacement personnel reach the division cycle level, they are placed in assimilation pools (a maximum of 10 pools). Those placed in the first pool are immediately available

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*In extreme cases that occur for units with a large number of crew-served weapons, a small number of noncrew personnel, high weapon replacement rates, and low personnel replacement rates, crew requirements for replacement weapons can exceed the current number of personnel in the pool. The pool is reduced to zero in this case and the excess requirement is filled as if sufficient personnel were available. Care should be taken in preparing input data so that this does not occur.

for distribution to the user units, those in the second pool will be available after one division cycle, etc. Input data identifies the fraction of personnel available during each cycle. The first pool accumulates both undistributed personnel and personnel moved up from the second pool in ensuing division cycles such that an excess of replacement personnel over personnel losses eliminates the effect of assimilation.

f. Red replenishment:

(1) On the Red side, the resupply of ammunition, POL, and other supply is provided to Red divisions in exactly the same way as it is to Blue brigades and units.

(2) However, one of two options may be chosen through an input selection that determines the form of replacement of men and major weapons. One option is to perform this replacement in the same manner as for the Blue side, i.e., to all units proportionally. The second option is to perform replacement to "decimated divisions" only. Red doctrine is to rebuild decimated divisions behind the lines and then to move the rebuilt divisions forward, allowing later decimated divisions to fall back for rebuilding. Thus the CEM pulls divisions out of the line when their state falls below a given threshold value and places them in a decimation pool where they become candidates for replacement of men and major weapons on the basis of need within the decimation pool.* After a division's status is rebuilt to the point that its state exceeds a given input threshold and a specified minimum time interval has elapsed, the division is again ready for combat. But if a division has not been rebuilt by the time a second specified minimum time input has elapsed, it is deactivated and its assets added to the pool of replenishments. If the second option (decimation) is chosen, the first option is inoperative. If the first option is chosen (on-line replacement), then the second option is still operative and comes into play if the state of an on-line division goes below the withdrawal threshold and at least one other division is in the Red corps. Therefore, through adjustment of replacement rates and decimation state thresholds, it is possible to exercise both options or option two only, when the second option is chosen. Another input allows the model user to specify a time period at the beginning of the simulation after which the Red replenishment will switch from decimation to on-line replacement.

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*In this case, those divisions having the least need are satisfied first.

g. Artillery ammunition:

(1) The problem of determining artillery ammunition expenditures is complicated by the fact that individual nondivisional artillery battalions lose their identities before they are employed in battle calculations. Therefore average expenditures are determined in the following way, on the assumption that all nondivisional GS battalions are equally likely to be assigned a DS role.

(a) Four classes of artillery battalion fire are handled in somewhat different manners. First, each DS battalion is employed in support of a specified brigade, so that the engagement types and expenditure values are known precisely for each of these battalions. And if one brigade is participating in more than one type of engagement by virtue of being opposed by two or more divisions with different missions, then the artillery expenditure is in proportion to the percentage of minisectors involved in each type of engagement.

(b) Second, each portion of divisional GS artillery battalion fire that is employed in the DS role is also used in support of specified brigades so that the engagement types and proportion of GS artillery fire employed in the DS role are known precisely for each of these battalions.

(c) Third, divisional GS artillery fire that is employed in the GS role expends ammunition in counterbattery fire and against reserve units. These battalions are identified by type, and thus the expenditure calculations can be accomplished directly through the use of the respective input values.

(d) Fourth, calculations for nondivisional GS battalions are made using the same rules as for divisional GS artillery (paragraph above), except that in this case averaging is done for the number of composite artillery battalions employed. This total ammunition expenditure is then apportioned to the different GS artillery types on the basis of the numbers employed and the normal expenditure rates for each type.

(2) If shortages of ammunition exist, each of the above calculations may be modified by the applicable constraining factor.

(3) The consumption and resupply of artillery ammunition is treated as a separate class of ammunition in the CEM to distinguish it from ammunition for the maneuver units.

6-7. SUMMARY OF DIVISION CYCLE

a. At the beginning of each division cycle, each brigade is characterized by its authorized status, its actual status, its parent organization, and (if on-line) its sector boundaries. The division has received allocations of fire support from corps.

b. The division estimate of the situation is made, leading to decisions concerning brigade mission, allocation of fire support to brigades, and commitment and/or reconstitution of the division reserve.

c. The engaged brigades in each sector are identified, the outcome of each engagement is determined, and the resulting changes in the FEBA are effected. Supply consumption is calculated and removed from the respective status files. Casualties and losses of major weapons are calculated, removed from the status files, and sent to their destinations (hospitals, out of theater, maintenance facilities, etc.).

d. Finally, the status of each brigade is improved with the allocation of resupply and with replacements of personnel and major weapons.

CHAPTER 7

TACTICAL AIR CYCLE

7-1. GENERAL FEATURES OF THE TACTICAL AIR CYCLE

a. Introduction. A schematic diagram is included as Figure 7-1 to illustrate the general features of the submodel. Aircraft are allocated to roles on a theater-wide basis according to an input strategy that is designed to direct efforts towards existing needs. Operations in the designated roles produce outputs which in turn affect the course of the air battle, the outcomes of individual brigade engagements, and subsequent aircraft role allocations. Being a theater function, decisions regarding allocation are performed (at the beginning of) each theater period. However, role operations are carried out on a continuing basis and results are examined prior to the next decision.

b. Types of Aircraft. All aircraft in the theater are represented by two composite or notional types. One of these is the air defense fighter (ADF) which includes those aircraft assigned to the role of air-to-air defense. The other type is the tactical fighter (TF) which includes those aircraft assigned to the remaining roles of attacking ground targets in enemy territory and in support of the friendly ground forces. The tactical fighters may also be employed as sweep fighters (SF), which are then armed for air-to-air combat and assigned to accompany and provide air-to-air protection of the TF aircraft which are penetrating enemy air-to-air defenses.

c. Aircraft Roles. Four roles are considered to which the flyable aircraft are allocated. These are:

(1) Air Defense Interceptor (ADI). This role is performed by the ADF aircraft only. They operate with the theater air defense system to engage enemy aircraft which penetrate friendly airspace.

(2) Counterair (CA). This is an offensive role to destroy enemy aircraft while parked on the airbases, enemy airbase facilities, surface-to-air missile (SAM) sites, and any other enemy systems which seriously threaten friendly air operations.

(3) Close Air Support (CAS). This role includes all strikes in support of ground forces under control of Division Air Liaison Officers (ALOs).

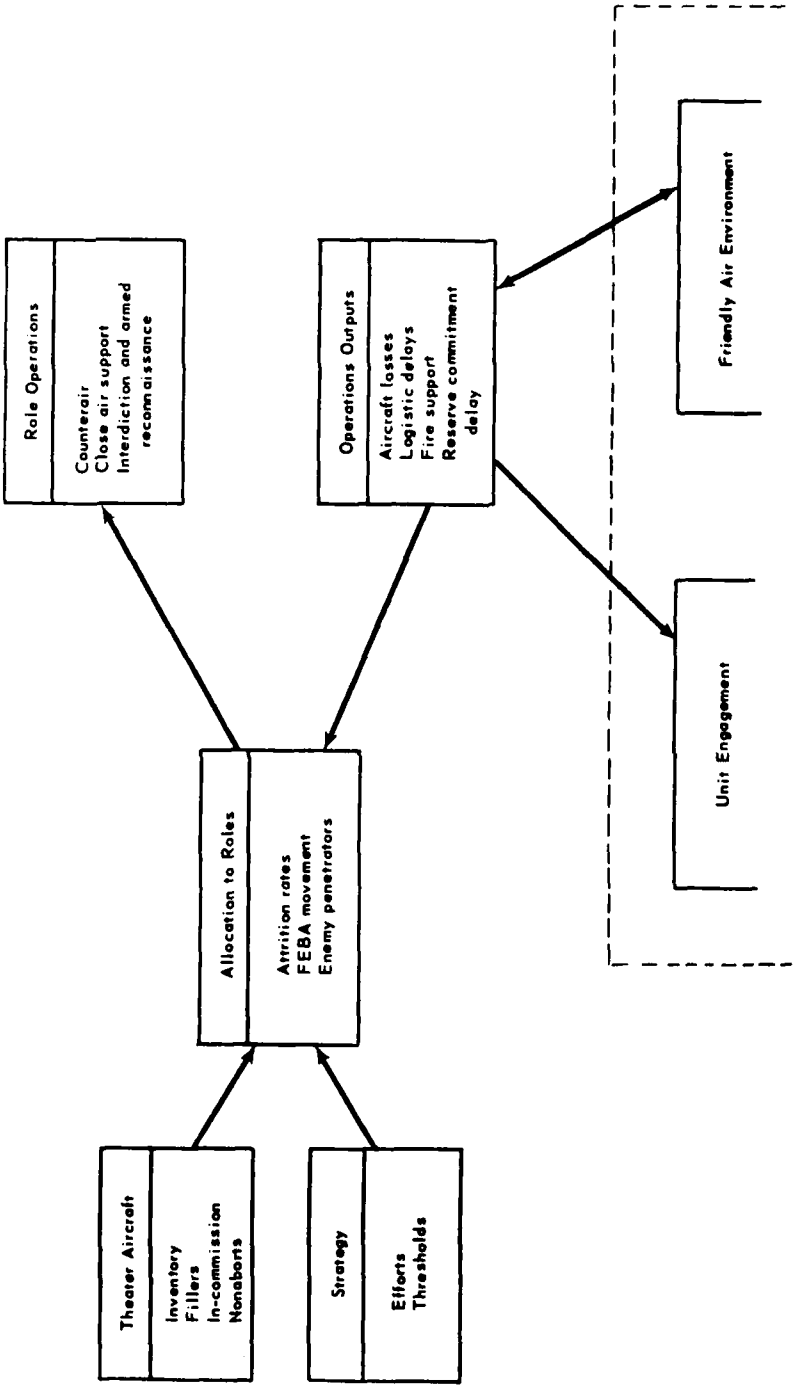

Figure 7-1. Tactical Air Submodel

(4) Armed Reconnaissance and Interdiction (AR/I). This role includes aircraft penetrating enemy airspace to destroy fixed and moving targets of general military significance.

d. Allocation

(1) The percentages of available TF aircraft to be applied to each role are provided as inputs for the first theater period, but these are modified in the subsequent periods according to aircraft loss rates in the air and on the ground. Loss rates are calculated over each theater period and compared to threshold levels that are supplied as inputs. (These thresholds represent maximum rates of air and ground losses above which sustained operations are in serious jeopardy.) The allocation percentages are subsequently modified by small increments depending on the results of the above comparison. These increments are drawn from inputs that are provided for each possible result of the comparison. The new percentage values hold for one day and are then modified daily by the same increments until the end of the theater period. Allowance is made, however, to radically alter the allocation percentages for any theater period so as to bring greater effort in support of the ground forces if the ground conflict has become desperate in the previous theater period.

(2) The ADF aircraft type is not included in the above allocation, but is handled separately. Although some of these aircraft, in reality, may have reasonable air-to-ground capability, they are generally configured specifically for air-to-air combat and perform that role much better than can the TF aircraft. To allocate aircraft back and forth between the air-to-air and air-to-ground roles then appears to be a complex operation due to the widely differing capabilities. In view of this and the need to keep this model highly aggregated, the allocation to ADF is handled as an input number. Judgments will be required according to the enemy threat and relative performance capabilties of friendly and enemy aircraft to establish the input. The value will then remain the same throughout the campaign.

e. Role Operations. The "action" in each role is handled each period independently of the other roles. Aircraft designated for CA participate in the CA battle for which the action is not at all influenced by the action of friendly aircraft in the other roles. Also, aircraft allocated to CAS are supplied to the ground forces for distribution and application as support to the ground forces without regard to activity in the other roles. Thus separate routines are employed to handle the aircraft in each role. ADE, CA, and AR/I roles work through the air submodel routines, but the CAS role works through the ground force combat model. Aircraft losses

in each role are recorded and supplied to the allocation routine for use in upcoming allocations.

(1) The CA role has the primary objective of attacking enemy air capability at its source of operations. Associated with this is also the task of attacking enemy air defense capabilities that interfere with carrying out both the CA and AR/I roles. This role requires deep penetrations into enemy territory.

(2) The AR/I role activity consists of attacking fixed and mobile targets in enemy territory. Such targets are those considered militarily significant and exclusive of those designated for CA attack. Penetrations into enemy territory are distributed at various distances with average distances less than those for the CA role. SF aircraft accompany TF aircraft performing AR/I and CA roles.

(3) The ADI role has the objective of intercepting incoming enemy aircraft over friendly territory. Small penetrations over enemy territory may take place if interceptions occur near the FEBA, but penetration would not normally be considered part of the role.

(4) The CAS role activity is handled by the ground force part of the CEM. Distribution of aircraft to combat units is accommodated, and the contribution of fire support made to engagement outcomes is counted. Rules for this distribution are contained in the CEM ground force model description.

f. Air Operations Outputs

(1) The outputs of the CA role are the number of enemy aircraft and SAM sites destroyed. The outputs affect the air battle primarily by reducing the threat to friendly air operations, but reducing the numbers of enemy aircraft also reduces the enemy CAS and AR/I threats.

(2) Although AR/I role aircraft have the objective to destroy targets, the model does not handle target destruction explicitly in this role. In reality, the effects of destroying such targets are disruption and delays in rear area supply and troop movements. Thus the output of this role is a delay in the delivery of the resources and the movement of reserves. The manner in which this is accomplished is described in detail in following description of Tactical Air Cycle.

... aircraft is reflected in the brigade ...

7-2. DESCRIPTION OF TACTICAL AIR CYCLE

a. Forces and Basing

(1) Tactical air forces for both sides are included. Initial forces are described according to the numbers and types of aircraft and their respective bases for operation. The many different types of aircraft are resolved to only two types, as described earlier. Each of these types represents the composite (or average) capabilities of all the various aircraft performing as one of each type. Forces include those in place at the beginning of the conflict and filler aircraft that can be brought into the conflict as it continues.

(2) Two types of airbases are included so that allowance can be made for some airbases to be immune from enemy air attack. Bases immune from air attack could result from political rules of engagement and/or range limitations of the enemy aircraft. These bases are designated as sanctuary (or secondary) operating bases. The other bases within range of enemy air attack and not excluded by other rules are subject to air attack and are designated as primary operating bases.

(3) Aircraft are based on primary or sanctuary bases according to their payload range capabilities. Once this division is determined, those based on primary bases are assumed to be equally distributed throughout the conflict among the primary bases available. All ADF aircraft are located on primary bases.

(4) As aircraft losses occur during the conflicts, filler aircraft, if available, are phased in to replace the losses. Filler aircraft consist of ADF and/or TF aircraft. They are brought in according to a predetermined augmentation schedule, based on theater periods, to replace losses of their respective types. The filler aircraft supply is not subject to enemy attack.

(5) The number of aircraft participating in any period depends on those in commission, the sortie rate, and the nonabort rate. The product of these factors is called the scramble rate in the model (SCR) and is an input number for each type of aircraft.

(6) The available aircraft are then allocated to their respective roles. Although all ADF aircraft are always allocated to the ADI role, they go through the process along with the other aircraft. Figure 7-2 is a schematic diagram of the model subsequent to the allocation of aircraft to roles. Each of the boxes on this diagram is discussed in the following paragraphs wherein the symbols are also defined.

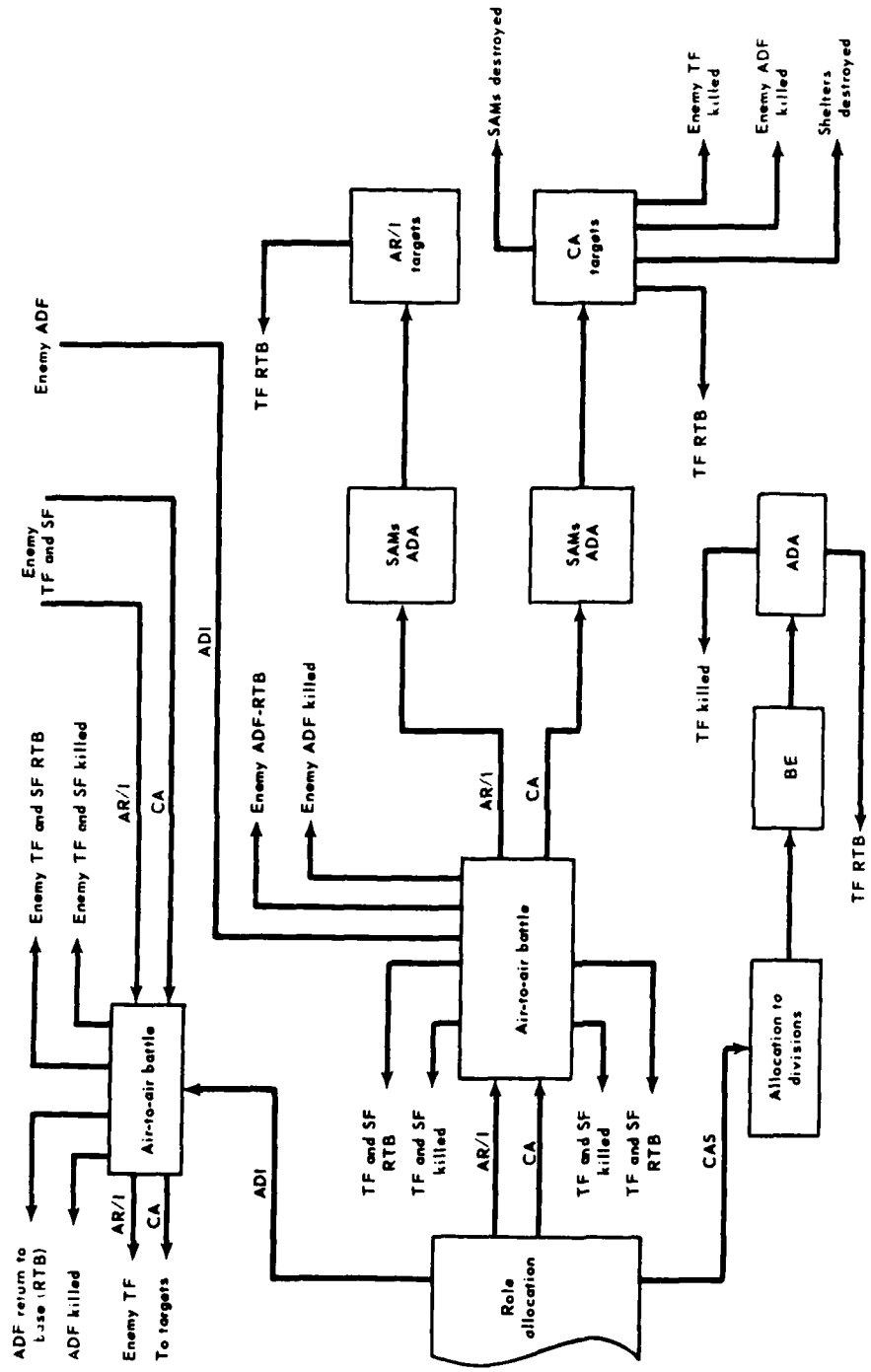

Figure 7-2. Schematic of Air Battle

b. Role Allocation

(1) Role allocation occurs once each day and holds throughout the day. Only TF aircraft are subject to changes in allocation, and the roles for these aircraft are CA, AR/I, and CAS. SF aircraft are drawn throughout the war from the allocation of TF aircraft to the CA and AR/I roles only in a constant proportion designated as sweep to tactical fighter ratio (STFR). Aircraft available for allocation are those which have survived on airbases and have returned from previous flying missions. Variations in this inventory occur through losses on airbases, losses in battle, and replacement or filler aircraft arriving in the theater on a theater period basis.

(2) Routine changes in allocation are based on three average attrition rates. These are by sortie in the AR/I and CA roles, and by theater period for aircraft losses on airbases. Attrition thresholds are supplied as inputs, which are representative of the maximum attrition rates acceptable for sustained operations. Actual attrition rates are then compared to the thresholds to see if changes in allocation should be made. The general nature of the changes may be towards reducing actual attrition (if it exceeds the thresholds) by increasing CA effort, or to increase CAS effort when actual attrition rates are less than the thresholds. If the attrition rates exceed thresholds, effort may be drawn from the AR/I and/or CAS roles and put into CA to counter the forces causing the high attrition. If this is successful in reducing the attrition rates below the thresholds, then effort may be withdrawn from CA and put into the AR/I and/or CAS roles. Changes in effort will be made in fixed percentage increments (supplied as inputs) of the total TF effort. Limits of both the maximum and the minimum efforts for each role will also be provided as input.

(3) Table 7-1 illustrates how inputs are provided, and how consequent changes in allocation may occur. The effort in each role is the percentage of available aircraft, initial effort being the effort for the first period. The thresholds are attrition rate thresholds as described above. The eight rows cover the eight possible combinations of results when comparing actual attrition to the thresholds. The three columns on the right indicate effort changes for the next period to be made for each of the eight possibilities. The percent figures are percentages of the total TF aircraft; the positive and negative signs indicate in which roles to add the increments and in which roles to subtract the increments.

Table 7-1. Example of Changes in Allocation (per day)[a,b]

Comparison results, actual attrition vs thresholds			Change increments to effort by role (%)		
AR/I	CA	Airbase	AR/I	CA	CAS
L	L	L	+2	-5	+3
L	L	H	+1	+4	-5
L	H	L	+2	-2	0
L	H	H	+2	-5	+3
H	L	L	-3	+4	-1
H	L	H	-5	+10	-5
H	H	L	-4	-6	+10
H	H	H	-4	-6	+10

[a] H - actual attrition > threshold attrition.

[b] L - actual attrition < threshold attrition.

Notes: If upper limit of effort in any role is achieved, transfers of effort calling for an increase to that role will be ignored.

If lower limit of effort in any role is achieved, transfers of effort calling for a reduction in that role will be ignored.

If lower limit in CAS role is achieved and transfers of effort call for reduction in CAS with addition to CA, then effort will be reduced in AR/I (if available) and added to CA.

Thresholds are attrition rates for theater period as follows:

$$\text{for CA, rate} = \frac{\text{all aircraft in-flight losses in CA role}}{\text{all sorties allocated to CA role}}$$

$$\text{for AR/I, rate} = \frac{\text{all aircraft in-flight losses in AR/I role}}{\text{sorties allocated to AR/I role}}$$

$$\text{for Airbase, rate} = \frac{\text{all aircraft lost on primary airbases each theater period}}{\text{all aircraft assigned to primary airbases at beginning of theater period}}$$

(4) Figure 7-3 is a schematic of this allocation process. Following attrition comparisons and determination of effort changes, allocation is made, using the resulting percentages of the number of flyable aircraft to each role for the theater period. The aircraft in the CA and AR/I roles are further divided between sweep fighter and tactical fighter functions within these roles according to the input STFR, the ratio of sweep fighter to tactical fighter aircraft on strike missions.

(5) Before allocation is final for this theater period, a check is made of the rate of movement of the FEBA for possible alterations in allocation. This rate of movement is the exponentially smoothed time average for all minisectors across the theater front (see para 5-2c, Defensive Positions). If the FEBA is stationary or moving forward, no effect on allocation occurs and allocation is made according to the table recommendations. However, if the FEBA is moving to the rear, then its rate of movement must be compared to two (input) thresholds. If the rate exceeds the lower threshold, then the aircraft designated for allocation to the AR/I role will be diverted to CAS. If the rate exceeds the higher threshold, then the aircraft designated for allocation to CA will also be diverted to CAS, with all sweep fighter aircraft being used as tactical fighter aircraft in CAS. If FEBA movement rates return below these thresholds, then allocations will return to the same values existent when the lower threshold override took place.

c. Air-to-Air Battle. Figure 7-4 is a schematic diagram of the air-to-air battle. After allocation, all TF and SF aircraft penetrate enemy airspace in which they encounter the enemy ADF aircraft. The enemy ADF aircraft are assumed to be operating in conjunction with an air defense control system which has some specified capability to detect incoming aircraft. The system then directs the ADF aircraft to these incoming aircraft for the purpose of intercepting and destroying the penetrating aircraft. There are essentially three stages of the air battle as seen in Figure 7-4. The first is that of detection by the control and warning system and its associated capability to place the ADF in the proper position to attack the penetrating aircraft. The second is the attack by the ADF aircraft to kill the penetrator. The third is the attack by the penetrator to kill the ADF (if the penetrator survived the attack by the ADF). The latter two may be reversed in order occasionally in real life and the probability of this occurring is included in the kill computations.

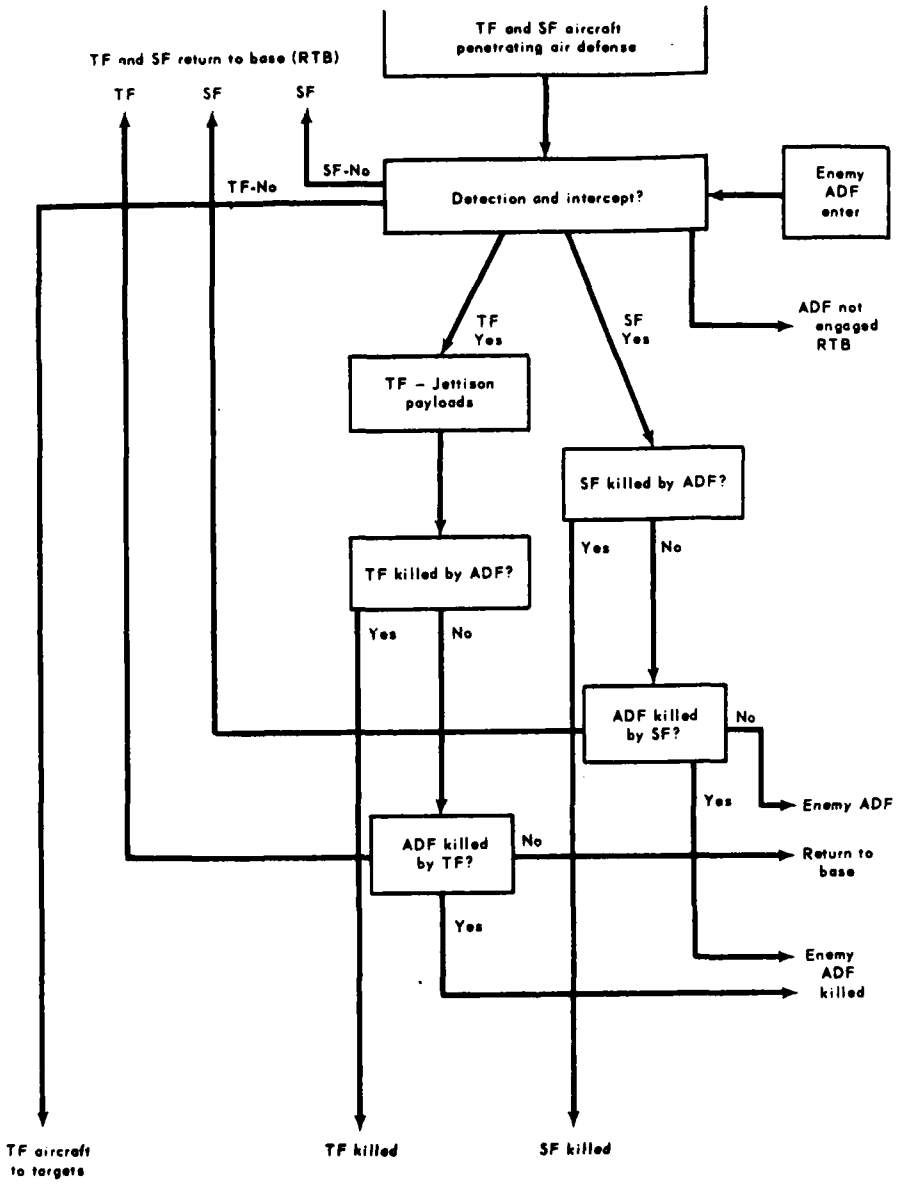

Figure 7-3. Schematic of Role Allocation Process

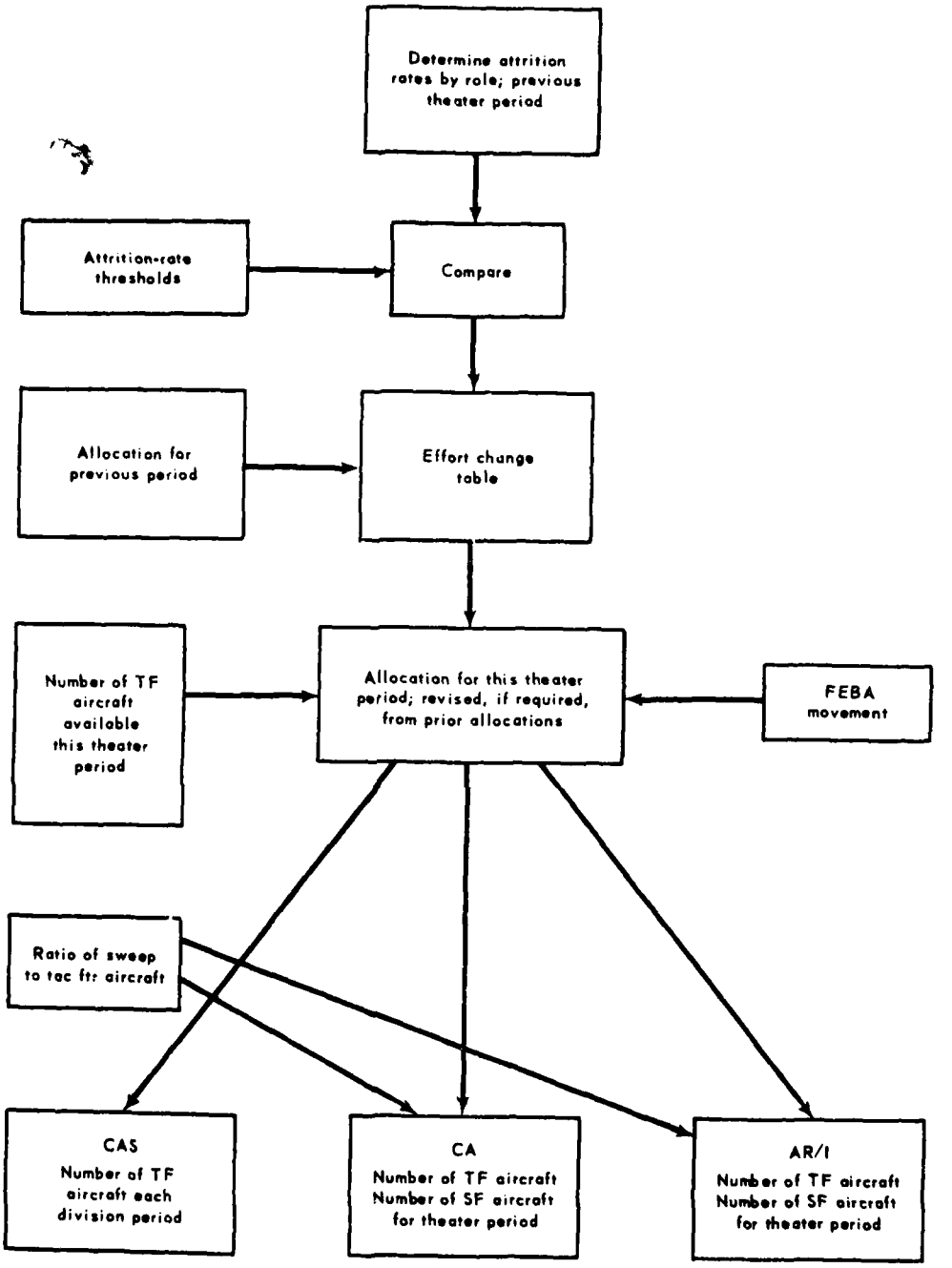

Figure 7-4. Schematic of Air-to-Air Battle

(1) A single probability (designated PDIP) is used to represent the entire intercept process against all penetrating aircraft. Included in this probability is the probability that the ground control system successfully detects the penetrator, the probability that the system has an interceptor aircraft available to employ in the engagement, and the probability the control system can place the interceptor aircraft in the proper flight position and vector to accomplish a successful intercept. This probability (PDIP) must represent the composite capability against the various aircraft flying at various altitudes and speeds. If P3 and S3 represent the number of TF and SF respectively in the AR/I role, P4 and S4 represent the TF and SF in the CA role, and I2 represents the number of ADF aircraft entering the battle; then the fraction of TF and SF not engaged (FRNE) by the ADF aircraft is:

$$FRNE = (1 - PDIP)^{I2/(P3+S3+P4+S4)}$$

(2) The TF aircraft not engaged proceed to their designated target areas in the CA and AR/I roles with the same proportion as previously allocated. The SF aircraft not engaged return to base without further incident.

(3) TF aircraft on their way to targets are loaded down with external ordnance and are in poor shape to do battle with or to escape from attacks by ADF aircraft. As a result, when the pilot of a TF aircraft becomes aware of a successful intercept by the air defense system and that the ADF aircraft is closing on him, he will jettison his payload and will seek to do battle with or to escape from the ADF in his best performance configuration. In this model it is arbitrarily assumed that the pilots of all TF penetrators successfully detected and intercepted become aware of impending ADF attacks and thus jettison their respective payloads.

(4) Since the ratio of intercept aircraft to penetrator aircraft is included above in determining the number of intercepts, the calculation of aircraft kills is based on the assumption that the ground control system directs one intercept aircraft to each detected penetrator aircraft. Thus each air-to-air engagement involves one ADF versus either one TF or one SF. The ADF, TF, and SF aircraft which survive an air-to-air engagement return to base without further incident; consequently, this is the only engagement between these aircraft for this period. Thus the expected number of TFs killed is simply the number of intercepts against TF aircraft times the probability (QIP) the ADF kills the TF, as follows:

$$P31 + P41 = (FRE)(P3+P4)(QIP)$$

where: P31 = number TF in AR/I role killed by ADF

P41 = number TF in CA role killed by ADF

FRE = 1 - FRNE.

Each TF surviving the attack by the ADF then has a probability (QPI) of killing the particular ADF that attacked that TF. Thus the expected number of ADF aircraft killed by surviving TF aircraft is:

$$I21T = (FRE)(P3+P4)(QPI)[1-(QIP)]$$

where: I21T = number ADF aircraft killed by TF.

(5) Similarly, the expected number of SF aircraft killed by the ADF aircraft is computed in the same manner, as follows:

$$S31 + S41 = (FRE)(S3+S4)(QIS)$$

where: S31 = number SF in AR/I role killed by ADF

S41 = number SF in CA role killed by ADF

QIS = kill probability of ADF against SF

also,

$$I21S = (FRE)(S3+S4)(QSI)[1 - (QIS)]$$

where: I21S = number ADF killed by SF aircraft

QSI = kill probability of SF against ADF.

d. Ground-to-Air Defense

(1) TF aircraft surviving the ADI battle next encounter theater (i.e., nondivisional) air defenses. These defenses consist of surface-to-air missiles (SAMs) and air defense artillery (ADA). The quantity of these defenses encountered naturally involves the depth of penetration and the types of targets attacked. For this reason, losses to aircraft in the AR/I role and in the CA role will differ, depending on the number of defenses encountered. Losses of TF aircraft to these defenses are calculated as follows:

$$Losses_{A,B} = (N_{A,B})(ATR_{A,B})(ADFUS)$$

where: $N_{A,B}$ = the number of aircraft penetrating these defenses in role A (AR/I) and role B (CA)

$ATR_{A,B}$ = attrition represented as aircraft killed per sortie, an input to the model with a value for role A and a value for role B, and developed by the following relationship:

$$ATR_{A,B} = (PK)(PE)(FE_{A,B})$$

where: PK = probability of kill, notional air defense fire unit against aircraft, given an engagement

PE = probability of engagement, notional air defense fire unit against aircraft

$FE_{A,B}$ = fraction of enemy notional air defense fire units encountered per sortie by aircraft in roles A and B

ADFUS = total number of enemy notional air defense fire units.

(2) This notional air defense fire unit may be arbitrarily defined as some small defense site, such as a single gun emplacement. The total number of ADFUS at any time then is based on the number of ADA and SAM units present times their respective conversion factors that identify the number of ADFUS per defending unit. Conversion factors are employed for ADA, low altitude SAMs, and high altitude SAMs. The quantity of ADFUS is reduced as SAM units are destroyed by air attack, but the quantity may be increased if replacement SAM units are provided. The replacement SAM units can only be provided according to an arrival schedule (developed prior to the running of the model) that is included in the CEM inputs. The types and quantities of SAM units arriving each theater period are specified.

e. Counterair Targets. The major targets for the CA role are aircraft parked on primary airbases. A distinction is made between those aircraft parked in the open and those in protective shelters due to the wide variation in vulnerability associated with each. The total number of shelters is specified, and it is assumed that aircraft left on the ground are in shelters up to the number of shelters existing at the time. Remaining aircraft are

parked in the open. Shelters attacked and destroyed will destroy the aircraft parked within.

(1) The number of shelters, as targets, is not diminished as it is assumed that repairs are made and that damaged shelters may conceal flyable aircraft.

(2) The number of aircraft subject to attack on a primary base during any time period is based on a constant at-risk fraction of the current inventory modified by losses occurring in the air within the current period of air combat. The at-risk fraction is a model input by type of aircraft (FARP for TF aircraft and FARI for ADF aircraft) which represents the effects of sortie rate, warning, average sortie duration, and the time that attacks can occur. These fractions may be developed by the following relationship:

$$FAR[P,I] = [1 - (SR[P,I] \bullet SD[P,I])/CH](1-PTO[P,I])$$

where: SR[P,I] = daily sortie rate for TF[P] and ADF[I] aircraft, respectively

SD[P,I] = average sortie duration in hours for TF and ADF aircraft, respectively

CH = combat hours in a day that airbases are subject to attack

PTO[P,I] = probability that the TF and the ADF aircraft take off from the /airbases upon warning of an impending attack.

(3) The attacks on the airbases are assumed to be distributed to all aircraft parking positions (shelters and open revetments) throughout the theater. The number of aircraft killed on the ground is dependent on the number at risk, the number of successful strike sorties attacking the bases over the theater period, and the vulnerability of the parked aircraft to the weapons delivered by the strike aircraft. Ordnance loads are assumed to be optimum for the aircraft capability and target vulnerability distribution.

(4) The number of aircraft lost (each half-day subperiod) to attacks on airbases is:

$$= AARO\left[1 - (1 - PAP)^{(1-FRSA)(EFO)(P9)/AARO}\right] +$$

$$(AAR - AARO)\left[1 - (1 - PSH)^{(1 - FRSA)(EFS)(P9)/SHE}\right]$$

where: AAR = total aircraft at risk = (P1P-LAR-LCA)(FARP)+(I1P-I21)(FARI)

FARP and FARI are at risk fractions for TF and ADF aircraft respectively

LAR = air losses in AR/I role, this subperiod

LCA = air losses in CA role, this subperiod

AARO = total aircraft at risk parked in open AARO = AAR - SHE (minimum of zero)

SHE = total number of aircraft shelters

FRSA = fraction of CA sorties allocated to attack of SAMs

PAP = kill probability against parked aircraft in open by each strike aircraft

PSH = kill probability against aircraft shelter by each strike aircraft

P1P = TF aircraft based on primary bases

I1P = ADF aircraft based on primary bases

I21 = ADF air losses, this subperiod

EFO = fraction of effort of strike aircraft attacking parked aircraft in open

$$EFO = \frac{AARO}{AARO+SHE} \qquad EFS = 1 - EFO$$

EFS = fraction of effort of strike aircraft attacking aircraft shelters

P9 = total number of successful strike aircraft attacking primary bases.

(5) Attacks on SAM sites are also a part of the CA role. It is assumed that such attacks would take place in some proportion to attacks on airbases, consequently, a fixed (input) fraction of CA aircraft sorties (FRSA) is allocated to attack the SAM sites. Aircraft attacking SAM sites have a probability PSA of destroying air defense fire units (ADFUS). Since the ADFUS are related to SAM sites by a conversion factor, then the number of SAM sites destroyed is the ADFUS destroyed divided by the conversion factor.

f. Armed Reconnaissance and Interdiction

(1) In actual warfare, the aircraft in this role attack LOCs, supply areas, vehicles, troop encampments, etc. The principal effects of such attacks include delays in supplies and resources being delivered to combat units, and commitment of reserve units above brigade level. In order to avoid the entangling process of counting all such targets and relating the effects of their destruction to front line combat unit effectiveness, the CEM does not treat their attack explicitly, but assumes that the effects of these attacks are dependent on the average rate of successful (surviving) aircraft sorties throughout the time period. If the rate is lower than an input friendly air environment threshold FAETH, then the affected ground forces are assumed to have a friendly air environment (FAE) and the flow of resources is normal. This includes all replacement and resupply items, as well as the movement of reserve units above the division level. If the rate exceeds the threshold, then the affected ground forces do not have FAE, and an additional delay is inserted in the flow of resources to the combat units and commitment of reserves. The existence of FAE for any theater period is determined at the beginning of the period, as a result of the calculations performed to determine the successful attack sorties for the period.

(2) In determination of FAE, the rate is the total number of AR/I and CA aircraft sorties for the theater period. Allowances for different loiter capabilities for the opposing sides may be reflected in establishing the threshold for each side.

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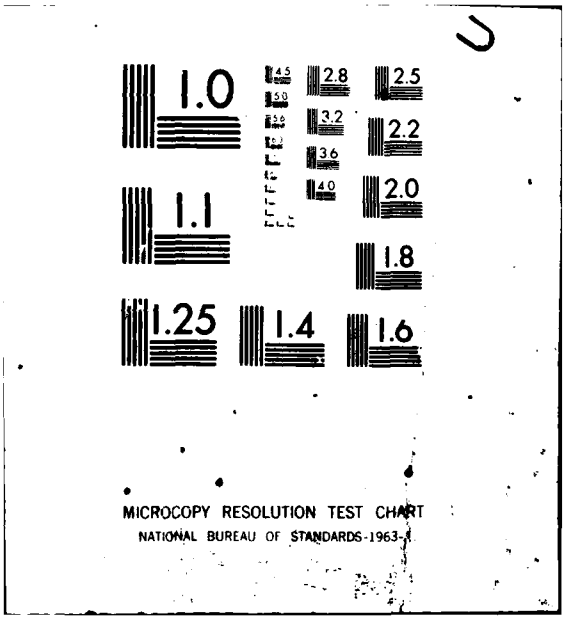
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g. Close Air Support

(1) Aircraft allocated to CAS are turned over to the ground force model for allocation to the combat divisions. They are then employed in the brigade engagements. Attrition is computed as a function of the number of enemy forces in each subsector engagement and the mission of the supported forces in each of these subsectors. Aircraft losses for each subsector engagement are tallied over the entire theater period.

(2) Losses are calculated for CAS aircraft at brigade level for Blue and division level for Red, summed across the front each division period, and these totals are then summed by division period through each theater period. The total losses are computed as follows:

$$P51_s = \sum_{d=1}^{8} \sum_{b=1}^{m} P51_{sdb}$$

where: d = division period

b = brigade (Blue) or division (Red) (total number = m)

$P51_{sdb}$ = CAS losses, side s, division period d, and brigade (Blue) or division (Red) b

Losses at brigade (Blue) or division (Red) level are computed as follows:

$$P51_{sdb} = (SPA1,2, \text{ or } 3_s)(SQCAS_{sdb})(GDA_0)(UOP_{OS})/WIDTH$$

where: $SPA1,2, \text{ or } 3_s$ = input (aircraft lost per squadron, per enemy AD fire unit, per division period) as a function of brigade (Blue) or division (Red), attack (1), defend (2), or delay (3))

$SQCAS_{sdb}$ = number of CAS aircraft squadrons supporting brigade (Blue) or division (Red) b, division period d, side s. This is the value that is used for engagement outcome determination

GDA_O = average air defense fire units, side O, per ground force unit (brigade for Blue and division for Red)

UOP_{OS} = total number of ground force units (brigade for Blue and division for Red), side O, opposing brigade (Blue) or division (Red) front, side s, summed over the subsectors of this side s unit's front

WIDTH = width of subsector in minisectors.

h. Air Defense Intercept. While friendly air forces are performing the above missions, enemy air forces will be performing the same type of missions against the friendly air forces. The ADF aircraft will be employed against these enemy penetrators in the same manner as described above in para 7-2c, Air-to-Air Battle.

7-3. RECAPITULATION

a. The tactical air cycle simulates air activity concurrent to the ground combat theater cycle. For convenience of computer operation, this simulation is accomplished at the beginning of each theater cycle for each division cycle of the upcoming theater period. The state of friendly air environment for each side and the number of available CAS aircraft are determined for application to the ensuing land warfare simulation.

b. Role allocation is determined on the basis of inputs and previous theater cycle results. Activity is then cycled through by division cycle length half-day subperiods for the ADI, AR/I, and CA roles. Sorties are flown, losses are determined, and the inventory is reduced by these losses each subperiod. When sufficient subperiods have occurred to represent the complete duration of a theater cycle, sorties and losses are summed for later use in reporting and attrition calculations. The aircraft designated for CAS are averaged on a daily rate and made available to the land warfare simulation for distribution during the ensuing theater cycle.

c. The existence of FAE is determined by summing all successful AR/I and CA sorties flown by the enemy over each side's occupied area. The state of FAE (or no FAE) is then applied to the land warfare simulation for the ensuing theater cycle.

d. Losses in CAS are dependent on the type of engagement and the number of enemy ADA units in the forces opposing each division being supported. These are summed over each division along the FEBA and for each division cycle, and reported back to the air model at the end of the theater cycle.

e. At the end of the theater cycle, the role attrition rates are determined, inventories for CAS losses are adjusted, and filler aircraft and replacement SAMs are added. The AR/I role attrition rate and the CA role attrition rate are determined by the ratio of the theater cycle losses to the theater cycle sorties in each role. The airbase attrition rate is the ratio of aircraft lost on airbases each theater cycle to the total aircraft assigned to these bases at the beginning of the theater cycle. Finally, filler aircraft and replacement SAMs are added to the inventories available for the next theater cycle.

CHAPTER 8

OUTPUT AND UTILITY OF THE CEM

8-1. GENERAL. The utility of the CEM lies in the degree to which useful knowledge can be derived from the information produced by one or more runs of the model. Information of value may be obtained directly from the examination of data produced by the model or by further treatment of the output data.

8-2. OUTPUT

a. The principal function of the CEM operation is to generate engagement situations, for which outcomes are determined and translated into two results: (1) FEBA movements and (2) changes in combat unit status. The results are then influential in establishing subsequent engagement situations. Principal outputs of the model are the distribution of engagement types; the missions decided upon at the various echelons; the FEBA locations; sector boundaries; the current states of all forces; current amounts of personnel, major weapons, and supplies; detailed accounting of Blue personnel; and combat losses by type of shooter. In addition, a composite status file report is presented for each theater cycle comparing current and authorized totals along with losses of personnel, major weapons, and supplies. On the Blue side, the reporting of personnel, supplies, and maintenance can be broken out among as many as three national partitions.

b. Other outputs are produced by relating the distribution of engagements by type and units participating to certain input rate factors. Artillery tonnage is calculated in this manner, using expenditure values as a function of the type weapon, the type of fire (GS or DS), and the type of engagement.

c. Outputs are also generated in the tactical air cycle. These include the current numbers of aircraft by type and basing, the current allocations among the functional roles, the aircraft losses occuring in the air and on airbases, and the current number of ADA and SAM sites. Other outputs from the air model include the ADA and SAM tonnages expended. These are calculated from input values of tons per aircraft shot down by each system.

d. Raw outputs of the CEM combat simulator are processed by a Report Generator program which averages and displays the output information.

8-3. UTILITY

a. The CEM can be utilized to simulate any theater-wide nonnuclear war that has a continuous FEBA. It is fully automated, and the combat for each theater-day is accomplished by the computer in a few minutes. As a result, force variations can be tested rather quickly in successive computer runs.

b. The output provides several measures whereby one force variation can be compared to another. These include the total displacement of the FEBA, the total resources expended by each side, the state of the forces during the campaign, and the time taken to arrive at these conditions.

c. The model can be used to study the mix of weapons in the combat forces. Many engagements at the multibattalion level occur throughout the campaign, and the outcomes of these engagements are affected by the mix of weapons on each side. The outcomes are also influenced by the environmental conditions as they relate to the types of combat weapons present.

d. The model may also be applied to the study of the sensitivity of combat results to resource resupply. As combat takes place, resources are expended and, as a result, the maneuver units are constrained with regard to the missions they may undertake and they are degraded in combat effectiveness. These capabilities are subsequently enhanced as new resources are received. The combat capability is sensitive to variations in such things as:

(1) The resupply capability for various classes of supply (POL, ammunition, and other supply),

(2) The personnel replacement rate,

(3) The theater evacuation policy,

(4) The replacement rates for specific major items of equipment, and

(5) The maintenance capability for these specific items of equipment.

e. Another area of application is the study of fire support/combat unit mix. The effects of artillery are accounted for in the manner in which such fire supports each engagement. This is also the case with regard to close air support from fixed-wing tactical aircraft.

f. Output from the CEM may also serve as input for further analysis. For example, information about the frequency of types of brigade engagement could serve as a guide in the application of higher resolution models to situations of special interest.

APPENDIX A

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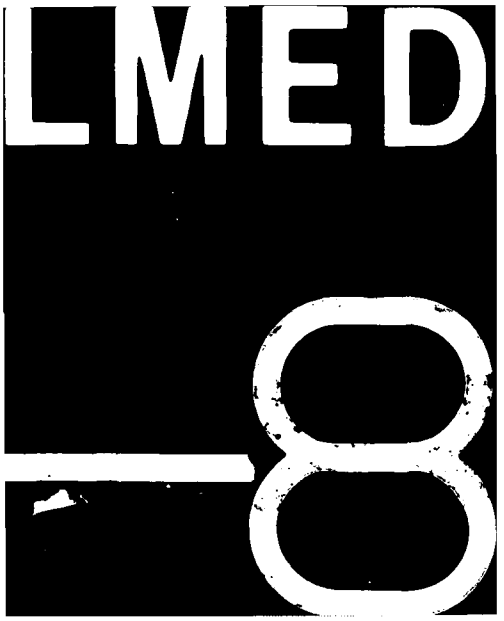
GLOSSARY OF TERMS

AAH	advanced attack helicopter
ADA	air defense artillery
ADF	air defense fighter
ADFUS	air defense fire units
ADI	air defense interceptor
AH	attack helicopter
ALA	antilight armor
ALA IFP	antilight armor index of firepower potential
ALO	air liaison officer
AP	antipersonnel
APC	armored personnel carrier
AP IFP	antipersonnel index of firepower potential
AR/I	armed reconnaissance and interdiction
ARIFP	army IFP ratio
AT	antitank
AT IFP	antitank index of firepower potential
BE	brigade engagements
BIF	battle intensity factor
BRIFP	brigade IFP ratio
C^3	command, control and communications
C^3I	communications, command and control, and intelligence
CA	counterair

CAA	US Army Concepts Analysis Agency
CAS	close air support
CB	counterbattery
CEM	Concepts Evaluation Model
CMIA	captured and missing in action
CONAF	Conceptual Design for the Army in the Field
CRIFP	corps IFP ratio
DNBI	disease and nonbattle injuries
DRIFP	division IFP ratio
DS	direct support
EEA	estimated expenditure of ammunition
FAE	friendly air environment
FEBA	forward edge of the battle area
FR	attacker-to-defender force ratio
GS	general support
HP	hasty position
IFP	index of firepower potential
KIA	killed in action
LA	lethal area
MIA	missing in action
MRD	motorized rifle division
PP	prepared position
RAC	Research Analysis Corporation
RF	range factor

RTB	return to base
SAM	surface-to-air missile
SCR	scramble rate
SF	sweep fighter
STFR	sweep to tactical fighter ratio
TF	tactical fighter
TOS	Tactical Operations Systems
TCM	Theater Combat Force Requirements Model
WIA	wounded in action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